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Memoirs of the Museum of Comparative Zoölogy
AT HARVARD COLLEGE.
Vol. XXXV. No. 5.

REPORTS ON THE SCIENTIFIC RESULTS OF THE EXPEDITION TO THE TROPICAL PACIFIC, IN CHARGE OF ALEXANDER AGASSIZ, BY THE U. S. FISH COMMISSION STEAMER "ALBATROSS," FROM AUGUST, 1899, TO JUNE, 1900, COMMANDER JEFFERSON F. MOSER, U. S. N., COMMANDING.

XIX.

THE DOLABELLINAE.

By F. M. MacFARLAND.

WITH TEN PLATES.

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INTRODUCTION.

A single specimen of a species of Dolabella was collected at Easter Island by the Tropical Pacific Expedition on 21 December, 1899. An excellent water-color sketch of the animal while living was made by Mr. Agassiz, and it was preserved in alcohol, being later placed in my hands for further study. In view of the notable lack of detailed information upon the anatomy of this genus, I deem the opportunity a valuable one for such a study, and the present paper is offered as a contribution to that end. In addition to the single specimen from Easter Island some use has been made of other specimens of a different species, *Dolabella hasseltii* (Férussac), collected at Samoa and given to me by my friend, Sir Charles Eliot, Vice Chancellor of the University of Hong Kong, China.

SYSTEMATIC CHARACTERS OF THE OPISTHOBRANCHIATA.

Marine Euthyneura with aquatic respiration; the ventricle of the heart is generally anterior, and the pallial cavity, when present, is widely open. There is a marked tendency to a reduction of the shell, which may become internal or disappear. In the naked forms spicules are sometimes developed.

Tectibranchiata.

Hermaphroditic opisthobranchiate Mollusca provided in the adult state with a mantle and shell, with certain exceptions; with one branchial plume and osphradium, with certain exceptions.

Aplysoidea.

Shell much reduced, more or less internal, or lost altogether in the adult state. Head with two pairs of tentacles. Margins of the parapodia separate from the ventral surface of the foot, and generally modified into natatory lobes.

Visceral commissure usually very much shortened, except in Tethys and Dolabella. Genital duct monaulic, the hermaphroditic duct connected with the penis by a ciliated groove.

Aplysiidae.

Animal lengthened, not protected by a shell, the neck and head narrower than the body; mouth a vertical fissure; anterior angles of the head produced into two tentacular lobes folded above; behind them the cylindrical or conical rhinophores, slit above, in front of which are the minute eyes. Parapodia recurved over the back, forming two lateral or dorsal lobes enclosing the mantle and ctenidium. Genital orifice between the dorsal lobes, communicating by a long furrow with the evertible penis, which is near the anterior right tentacle. Shell nearly or entirely covered by the mantle, uncoiled, in the form of a concave plate, or absent. Mouth with corneous jaws and a large multiserial radula composed of similar teeth; stomach armed with horny nodules; anus behind the branchial plume.

Aplysiinae.

Parapodial lobes well developed, their anterior ends separated; genital orifice in front of the ctenidium; radula with wide denticulate rhachidian teeth, and narrower serrate and denticulate laterals. Shell flexible.

Dolabriferinae.

Parapodia considerably united behind, in front contiguous, separated only by the spermatic furrow; genital orifice in front of the ctenidium; shell calcareous or absent; radula with well-developed rhachidian teeth, larger than the laterals.

Dolabellinae.

Parapodia scarcely mobile, united behind, inclosing a large branchial chamber, their anterior ends contiguous, separated by the spermatic furrow; the dorsal slit short. Posterior part of body obliquely truncate, bounded by a ridge; Genital orifice usually under the posterior part of the ctenidium; radula with the rhachidian tooth rudimentary or nearly so, laterals very numerous with long simple cusps; shell well developed, calcareous.

DOLABELLA Lamarck, 1801.

Dolabella Lamarck, Système anim. sans vertèbres, 1801, p. 62.
Aplysia (in part) Rang, Hist. nat. aplysiens, 1828, p. 36.
Dolabella Pilsbry, Tryon's Manual conch., 1896, **16**, p. 150.

General body-form conic, wide and obliquely truncate behind, narrower in front. Integument more or less warty. Head bearing in front a pair of subcylindrical buccal tentacles, slit above; rhinophores much nearer the anterior margin than to the dorsal slit, similar to those of Tethys. Eyes minute, in front of the rhinophores; posterior area of the body defined by an obliquely transverse ridge. Parapodial lobes united save for a dorsal slit, more open at the ends, the anterior insertions of the lobes contiguous, parted only by the spermatic groove. Mantle not nearly covering the ctenidium, produced in a folded siphon behind. Branchial cavity very large. Genital orifice usually under the posterior portion of the ctenidium, penis very long, near right buccal tentacle. Hypobranchial gland multiple.

Shell solid and calcareous, hatchet shaped, loosely coiled, the free spire obliquely decurved, heavily calloused; sinus deep and concave; margins reflexed.

Type:— *Dolabella scapula* (Martyn, 1786).

The earliest record of this form is found in D'Amboinsche Rariteitkamer and in the Thesaurus imaginum Piscium Testaceorum, of Georg Eberhard Rumpf, printed in Amsterdam, the first named in 1705, and the second in 1711, the same plates being used in each. Figure 5 of Plate **10** represents the animal designated as "*limax marina tertia*," while fig. 12 of Plate **40** reproduces the shell, which is termed "*tertia species operculi callorum.*" That the shell so figured belonged to the animal shown on Plate **10**, was not positively known until the dissections made by Cuvier (1804) of specimens collected by Péron at Mauritius, confirmed the statement of the latter as to the identity of the two forms. The same shell was figured by Martyn in the Universal conchologist in 1786, Plate **99**, with the binomial name *Patella scapula*. In 1801 Lamarck established the new genus Dolabella for the shell figured by Rumph, with the name *Dolabella callosa*, which is of course antedated by the publication of Martyn, the genotype being now recognized as *Dolabella scapula* (Martyn).

Our anatomical knowledge of the genus is mainly drawn from the brief descriptions of Cuvier (1804), the monograph of Rang (1828), and the more recent works of Amaudrut (1886), Mazzarelli and Zuccardi (1890), Gilchrist (1894), Lacaze-Duthiers (1898), Eliot (1899), and Bergh (1905, 1907); all of which are more or less fragmentary.

The genus Dolabella so far as is known is confined to the Indo-Pacific area, ranging westward to the Red Sea and the Cape of Good Hope, eastward to the Gulf of California, the West coast of Mexico and the Gulf of Guayaquil, and southward to New South Wales. Quite a number of species have been described, most of them in an incomplete manner, and all are in need of careful detailed study and revision. Pending this the following chronological list includes all apparently valid species, though some of them may be found later to be but varieties of a few widely distributed forms.

1. **Dolabella scapula** (Martyn), 1786.

Patella scapula Martyn, Univ. conchol., 1786, **3**, pl. 99.

?Doris verrucosa Gmelin, Syst. nat., ed. 13, 1791, pt. 6, p. 3103; Barbut, Genera Vermium, 1788, **2**, pl. 4, f. 1.

Dolabella callosa Lamarck, Syst. anim. sans vertèbres, 1801, p. 62.

Dolabella sp. Cuvier, Ann. Mus. hist. nat., 1804, **5**, p. 437–440, pl. 29, f. 1–4.

Dolabella rumphii Cuvier, Règne anim., 1817, **2**, p. 398, pl. 34, f. 1; Lamarck, Hist. nat. anim. sans vertebres, 1822, **6**, pt. 2, p. 41; Ed. 2, 1836, **7**, p. 699; Krauss, Südafrikanischen moll., 1848, p. 72; Adams and Reeve, Zool. Samarang. Moll., 1848, p. 65, pl. 17, f. 4; Brazier, Proc. Linn. soc. N. S. W., 1878, **2**, p. 88; Martens, Moebius's Beitr. meeresfauna Mauritius, 1880, p. 306; Smith, E. A., Rept. zool. coll. H. M. S. Alert, 1884, p. 89; Bergh, Siboga expedition. Opisthobranchiata, 1905, p. 13, taf. 7, f. 22–40; taf. 8, f. 1–7; Vayssière, Ann. Fac. sci. Marseille, 1906, **16**, p. 51, pl. 1, f. 1–5; Clessin, Martini and Chemnitz's Syst. conchylien-cabinet, 1899, **1**, 8, p. 24, taf. 11, f. 7.

Aplysia rumphii Cuvier, Rang, Hist. nat. aplysiens, 1828, p. 46, pl. 1; Quoy and Gaimard, Voy. Astrolabe. Zool., 1832, **2**, p. 303, pl. 23, f. 4, 5.

Dolabella peronii Blainville, Dict. sci. nat. 1819, **13**, p. 395; Manuel malacol., 1825–1827, p. 472, pl. 43, f. 5.

Dolabella scapula Martyn, Adams, H. and A., Gen. recent Moll., 1854, **2**, p. 32, pl. 59, f. 3, 3a; Angas, Proc. Zool. soc. London, 1867, p. 227; Pilsbry, Tryon's Manual conch. 1896, **16**, p. 152, pl. 26, f. 26–28; pl. 27, f. 29–30; Farran, Rept. Ceylon pearl oyster fisheries, 1905, no. 21, p. 354, pl. 5, f. 16, 17; Hedley, Proc. Australasian assoc. adv. sci., 1910, p. 371.

Habitat:— Widely distributed in the Indian Ocean and Western Pacific areas.

2. **Dolabella ecaudata** (Rang), 1828.

Aplysia ecaudata Rang, Hist. nat. aplysiens, 1828, p. 47, pl. 2.

Aplysia truncata Rang, Hist. nat. aplysiens, 1828, p. 47.

Aplysia tongana Quoy and Gaimard, Voy. Astrolabe. Zool., 1832, **2**, p. 305, pl. 23, f. 6, 7.

Dolabella tongensis Gray, Figures moll. anim., 1850, 4, p. 97, pl. 137, f. 1.

Dolabella ecaudata Rang, Brazier, Proc. Linn. soc. N. S. W., 1878, **2**, p. 89; Pilsbry, Tryon's Manual conch., 1896, **16**, p. 157, pl. 25, f. 4, 5; pl. 66, f. 11, 12, 13; Clessin, Martini and Chemnitz's Syst. conchylien-cabinet, 1899, **1**, 8, p. 25, taf. 10, f. 5; Hedley, Proc. Australasian assoc. adv. sci. 1909, p. 371.

Dolabella tongana Quoy and Gaimard, Mazzarelli and Zuccardi, Boll. Soc. nat. Napoli, 1889, **3**, p. 120; Mem. Soc. Ital. sci., 1890, ser. 3, **8**, p. 9, tav. 1, f. 3, 8, 12, 14, tav. 2, f. 3, 6, 13.

Habitat:— Moluccas, Philippines, Tonga Islands, Samoa, N. E. Australia.

3. **Dolabella teremidi** (Rang), 1828.

Aplysia teremidi Rang, Hist. nat. aplysiens, 1828, p. 48, pl. 3, f. 1–3.
Dolabella teremidi Lesson, Voy. Coquille. Zool., 1830, **2**, pt. 1, p. 293; Lamarck, Hist. nat. anim. sans vertèbres, ed. 2, 1836, **7**, p. 700; Deshayes, Moll. Île Réunion, 1863, p. 53.
Dolabella temnida Gray, Figures moll. anim., 1850, **4**, p. 97.
Dolabella termida Gray, Figures moll. anim., 1850, **4**, p. 29.
Dolabella teremidi Martens, Moebius's Beitr. meeresfauna Mauritius, 1880, p. 306; Mazzarelli and Zuccardi, Boll. Soc. nat. Napoli, 1889, **3**, p. 120; Mem. Soc. Ital. sci. 1890, ser. 3, **8**, p. 7, tav. 1, f. 2, 9, 12, tav. 2, f. 2, 9; Pilsbry, Tryon's Manual conch., 1896, **16**, p. 154, pl. 63, f. 9–11; Clessin, Martini and Chemnitz's Syst. conchylien-cabinet, 1899, **1**, 8, p. 27, pl. 10, f. 8.
Dolabella hasseltii Fér, Eliot, Proc. Acad. nat. sci. Phila., 1899, p. 516.

Habitat:— Society and Caroline Islands, Réunion Island, Samoa, Philippines.

4. **Dolabella gigas** (Rang), 1828.

Aplysia gigas Rang, Hist. nat. aplysiens, 1828, p. 48, pl. 3, f. 4.
Dolabella gigas Deshayes, Moll. Île Réunion, 1863, p. 53; Sowerby, Conch. icon., 1868, **16**, pl. 1, f. 1a, b; Martens, Moebius's Beitr. meeresfauna Mauritius, 1880, p. 306; Pilsbry, Tryon's Manual conch., 1896, **16**, p. 152, pl. 65, f. 4, 5, 6; Clessin, Martini and Chemnitz's Syst. conchylien-cabinet, 1899, **1**, 8, p. 26, pl. 10, f. 2.

Habitat:— Mauritius, Réunion Island, Red Sea.

5. **Dolabella hasseltii** (Férussac), 1828.

Dolabella rumphii Van Hasselt, Lettre sur les mollusques de Java. Bull. sci. nat., 1824, no. 2, 3, 4.
Aplysia hasseltii Férussac, Rang, Hist. nat. aplysiens, 1828, p. 49, pl. 24, f. 1; Quoy and Gaimard, Voy. Astrolabe. Zool., 1832, **2**, p. 306, pl. 23, f. 1–3.
Dolabella hasseltii Fér., Lamarck, Hist., anim. sans vertèbres, ed. 2, 1836, **7**, p. 700.
Dolabella variegata Pease, Proc. Zool. soc. London, 1860, p. 32.
Dolabella hasseltii Fér., Martens, Moebius's Beitr. meeresfauna Mauritius, 1880, p. 306; Mazzarelli and Zuccardi, Boll. Soc. nat. Napoli, 1889, **3**, p. 47; Mem. Soc. Ital. sci. 1890, ser. 3, **8**, p. 3, tav. 1, f. 1, 6, 7, 11, 16, 18–21, tav. 2, f. 1, 8, 17; Pilsbry, Tryon's Manual conch., 1896, **16**, p. 154, pl. 64, f. 3.

Habitat:— Mauritius, Java, Timor, Philippines, Hawaii.

6. **Dolabella hemprichii** Ehrenberg, 1828.

Dolabella hemprichii Ehrenberg, Symbolae physicae. decas 1, 1828, 1831; Pilsbry, Tryon's Manual conch., 1896, **16**, p. 156.

Habitat:— Casseir, Red Sea, Gulf of Aden.

7. **Dolabella guayaquilensis** Petit, 1868.

Dolabella guayaquilensis Petit, Sowerby's Conch. icon., 1870, **16**, pl. 2, f. 6a, b; Sowerby, Pilsbry, Tryon's Manual conch., 1896, **16**, p. 160, pl. 64, f. 1, 2.
Dolabella quayaquilensis Petit, Clessin, Martini and Chemnitz's Syst. conchylien-cabinet, 1899, **1**, 8, p. 26, taf. 10, f. 6, 7.

Habitat:— Coast of Ecuador, Guayaquil.

8. **Dolabella elongata** Sowerby, 1868.

Dolabella elongata Sowerby, Conch. icon., 1870, **16**, pl. 1, f. 2a, b; Pilsbry, Tryon's Manual conch., 1896, **16**, p. 156, pl. 27, f. 31, 32; Clessin, Martini and Chemnitz's Syst. conchylien-cabinet, 1899, **1**, 8, p. 25, taf. 10, f. 3, 4.

Habitat:— Indian Ocean, Seychelles Islands.

9. **Dolabella californica** Stearns, 1878.

Dolabella californica Stearns, Proc. Acad. nat. sci. Phila., 1879, p. 395, pl. 7, f. 1, 2; Proc. U. S. N. M., 1893, **16**, p. 341; 1894, **17**, p. 158; Pilsbry, Nautilus, 1895, **9**, p. 73; Tryon's Manual conch., 1896, **16**, p. 159, pl. 66, f. 14–16.

Habitat.— Mulege Bay, Gulf of California, West Coast of Mexico.

10. **Dolabella neira** Sowerby, 1899.

Dolabella neira Sowerby, Clessin, Martini and Chemnitz's Syst. conchylien-cabinet, 1899, **1**, 8, p. 27, taf. 10, f. 1.

Habitat:— Banda Neira Island, Moluccas.

A comparison of the Easter Island specimen with the descriptions of the other known Dolabellinae renders it clear that it represents a new and undescribed species. I take great pleasure in naming it in memory of our great zoölogist and oceanographer, Alexander Agassiz.

Dolabella agassizi, n. sp.

Length 160 mm. or more, the maximum diameter 80 mm., greatest circumference 210 mm., at epipodia, tapering forward to 105 mm., at the anterior end of the bluntly conical body. Parapodia low, thick and fleshy, the dorsal slit between them one third the body-length. Posterior disc large, bounded by a smooth ridge. General surface of the body smooth, slightly tuberculate in the head-region, but destitute of cirrhi or processes. Anterior tentacles and rhinophores cylindro-conic, close together, separated by about 1/10 the body-length, bases of the rhinophores moderately wide apart.

Color light copper-green, the inner edges of the parapodia and (at least) the anterior floor of the pallial chamber vinous purple.

Shell moderately large and strong, hatchet shaped, covered with light amber cuticle. Spire loosely coiled, heavily calloused and rough. Margin broadly reflexed dorsally behind, lessening and disappearing in front. Posterior sinus deep with a narrow reflexed dorsal margin. Length 54 mm., breadth 31 mm., altitude 6.0 mm.

Habitat:— Easter Island, South Pacific Ocean.

EXTERNAL CHARACTERS.

General form and color.— The single specimen of this species was taken in shore collecting at Easter Island. The colored figure upon Plate 1 is reproduced from a water-color drawing, painted from life by Mr. Agassiz. No notes accompanied the drawing other than the memorandum that the color "should be a little more copper-green." A comparison with other figures of different members of the Dolabellinae, notably those given by Rang (1828), would indicate that this specimen was probably somewhat contracted, and not moving about freely while being painted. In the preserved condition the body-form is bluntly conical, its posterior end being abruptly terminated by an oblique disc from above backward, with prominent smooth and slightly sinuous outlines. The general surface of the body, save for general longitudinal corrugations manifestly due to shrinkage, is fairly smooth, a few low scattered tubercules being recognizable along the dorsum and in the head-region, as shown in Plate 1. Nothing resembling the highly developed fleshy processes or cirrhi, characteristic of most described species, is present. In this respect it resembles *Dolabella ecaudata* (Rang) more than any other form. Shrinkage has caused the posterior disc to be set off from the otherwise smooth surface of the foot by a deep ditch-like corrugated area.

The anterior end of the body is bluntly rounded, and is so strongly invaginated that the tentacles and mouth-parts are completely introverted into a cavity. From the figure, Plate 1, it is seen that the anterior tentacles are short and bluntly cylindrical, while the rhinophores are of the same general shape, their bases not close together, but set far forward on the head, more so than in other species. On careful eversion the anterior tentacles are found to be rather narrowly auriculate, while the rhinophores are of the same cylindrical form, with a narrow longitudinal groove upon their outer posterior margin.

Dimensions.— In the preserved specimen the greatest length of the animal is 16.0 cm., and its greatest transverse diameter is 8.0 cm. The circumference at the highest point of the epipodia is 21.0 cm., tapering to 10.5 cm. at the anterior end of the body. The posterior disc is 8.0 cm. in transverse diameter, and 5.5 cm. in vertical height, its circumference measuring 25.5 cm. The total length of the epipodial slit is 7.58 cm., its anterior end being nearly midway of the body-length. No measurements are at hand of the animal during life, but they were probably considerably greater than those here given.

Foot.— The ventral surface, or foot, passes uninterruptedly over into the sides of the body and is uniformly smooth, save for contraction rugae in its anterior and posterior portions. The anterior end of the foot is curved upward and invaginated with the whole head-region.

Epipodia.— The epipodia are thick and fleshy, scarcely mobile, and are united behind the siphon at the upper side of the posterior disc for a distance of 27 mm. They are short and low, with thick closely interlocking margins, in front sloping rapidly downward to a low ridge-like fold, which terminates just in front of the middle of the length of the animal. The anterior ends of the epipodia are 4 mm. apart, but little more than the width of the genital groove, which emerges between them. Inclosed within the low margins lies a smooth flattened area of elongated oval shape, limited behind by the anterior edge of the mantle. It is 28.7 mm. in length and 15.6 mm. in greatest width. In Plate 1 this shows a light purple color, which also appears on the inner margins of the epipodia, and doubtless extends inward over the walls of the pallial cavity to a greater or less extent.

The closely appressed margins of the epipodia fit snugly together with interlocking grooves and ridges, leaving an anterior opening for the inflow of water, and a posterior rounded one, somewhat above the centre of the disc for its exit. On reaching this posterior foramen, the inner thin edge of the epipodium curves over to the outside of the margin, and is prolonged around the opening in an irregular curve on the face of the disc, receding from and approaching the thickened edge of the opening in a number of sinuous bays. The boundary of these bays is a low sharp-edged fold, averaging 1 mm. in height, and incloses an area not appreciably different in its surface texture from the remainder of the posterior disc. No trace of this is to be seen on Plate 1, nor have I found anything similar in *D. hasseltii*. Its significance is unknown.

The external spermatic groove appears from beneath the anterior end of the mantle, and continues forward in the median line as a sharply defined furrow with prominent margins. At the anterior end it diverges to the right and enters the invaginated portion of the body in the preserved specimen. As seen in Plate 1, in the living animal it curves forward and downward to the right below the base of the right rhinophore, to the opening of the penis-sheath, which it enters below the right tentacle.

Pallial complex.— Separating the margins of the epipodia a roomy cavity is disclosed, the mantle, covering the ctenidium, partially dividing it into an upper and a lower chamber, which communicate widely at the right side. In

the centre of the dorsal surface of the mantle the shell is visible through the large triangular shell-foramen. This opening, (Plate 6, fig. 1, *l*) is nearly of the form of an isosceles triangle, the apex directed forward, and measures 23.5 mm. in length. In Plate 6, fig. 1, the relations of the mantle to the other organs of the pallial cavity are represented, the ctenidium, however, being omitted. The epipodia have been removed, the outline of their bases being represented by the continuous line *a*, while the dotted line *k* indicates the projection of their upper margins upon the structures below. The mantle is attached to the dorsal wall of the body to the left of the dotted line *c*, which represents the outline of the shell, the triangle *l* indicating the widely open foramen of the latter. Near the median line in front, above and to the left of the spermatic furrow *i*, the free margin of the mantle begins, and is shown by the continuous line *d*, which passes in a gentle curve to the right and backward, then more sharply to the left side, where it is continued into an erect auriculate lobe, the siphon, *s*. The siphon is highest on the left side, and behind rapidly descends around the anal opening, *f*, as a thin low fold of integument, which continues to the right and forward as a stronger fold, *g*, 2.5 mm. in height, along the floor of the branchial cavity to the common reproductive opening *h*, the upper margin of which it forms (Plate 4, fig. 3, *a*). The ventral surface of the mantle is very glandular and of a dark brown color. Toward the posterior margin it is thickened and reflected in a prominent flap *e*, as noted by Gilchrist (1894), for *D. rumphii* [= *scapula*]. In the Easter Island species, however, the reflected lobe is present only at the right posterior angle of the mantle, where it is quite large, the reflected margin extending so far as to overlie a portion of the shell-cavity.

The rear wall of the pallial chamber is formed by the union of the epipodial lobes behind the siphon, the main portion of the oblique posterior disc of the body being made up of the fused epipodia. The round excurrent foramen is 20 mm. above the floor of the pallial cavity at the base of the posterior wall. Above the mantle the roomy pallial cavity extends downward upon the left side nearly as far as upon the right.

Figure 5 of Plate 6 represents the pallial organs as disclosed by the removal of the most of the mantle. It has been cut away along the double line *m*, which represents its section close to its origin from the dorsal body-wall. As in Plate 6, fig. 1, the line of the base of the epipodia is represented by *a*, the dotted line *k* indicates the projection of their free upper margin, while *b* is the circumference of the oblique posterior disc. Below the mantle the relatively large ctenidium is shown, its free portion curving backward in the pallial cavity in almost a

complete circle, the tip resting in the siphon. The afferent and efferent vessels of the ctenidium are indicated by *af* and *ef* respectively, and all that portion of the gill lying to the right of a line joining these two points is the free portion, while the remainder on the left is attached in front and behind to the body-wall. The ctenidium is of the folded type, the folded portions alternating above and below the gill-axis. Between each set of folds on either side is found an oval opening leading into the reverse side of the corresponding folds of the opposite face of the gill. These openings are represented in the figure by the row of darkly shaded areas upon the dorsal surface of the ctenidium. Similar openings are to be found, alternating with these upon the ventral side. The length of the ctenidium, measured along its outer margin, is approximately 90.0 mm., 22.0 mm. of this being along the attached area.

At the anterior end of the ctenidium upon its ventral surface, is a small elongated depression (Plate 6, fig. 5, *o.*) with rather prominent boundaries, the osphradium. It lies directly in the path of the inflowing current of water between the parapodia.

The external spermatic groove, *i*, leads back to the genital opening, *h*, lying below the anterior portion of the ctenidium. The position of this opening does not agree with that given by Pilsbry in Tryon's Manual, 16, p. 150, in which the location of the genital opening beneath the posterior part of the ctenidium is stated to be one of the characteristics of the Dolabellinae. A similar location in front of the middle of the gill is also found in all the specimens of *D. hasseltii* that I have examined.

The anus is a pocket-like opening situated just within the low posterior wall of the siphon, slightly to the right of the median line. Its margin is scarcely elevated, save in front.

The posterior mantle-margin is continued into the siphon, (Plate 6, fig. 1, 5, *s*), the left and anterior walls of which reach a height of 7.0 mm. The posterior wall drops down rapidly into a scarcely perceptible fold behind the anus. In this form it may be traced to the right and downward to rise into a well-marked fold or ridge, which continues forward on the floor of the pallial chamber to the genital opening, (Plate 6, fig. 1, *g*). In the median line, in front and to the right of the base of the siphon, a thickening in the floor of the pallial chamber forms a nearly circular disc, or button. The thickened margin of this disc is best developed on the right side, and is elevated ca. 3.5 mm. above the floor of the pallial chamber, becoming slightly less in front, (Plate 6, fig. 1, *n.*, fig. 5, *c.*). As pointed out by Gilchrist (1894) a similar button-like elevation in

D. rumphii [= *scapula*] might be raised so as to close the posterior opening completely, when the epipodial margins are closely appressed, thus converting the pallial cavity into a sac, open only in front. He suggests that the forcible ejection of the water contained in this cavity under such conditions might suddenly propel the animal backward, as is done in the nearly related Notarchus (Vayssière, 1885, p. 81) and in the Cephalopoda. No record has ever been made of any such habit so far as I am aware.

The hypobranchial gland, or organ of Bohadsch, is a diffuse structure made up of an enormous number of tubules opening independently in the floor of the pallial chamber at the right of the genital opening and the spermatic groove. It extends from the anterior end of the chamber backward as far as the posterior end of the base of the ctenidium and the region of the rectum, the total area occupied being somewhat semicircular in outline, and reaching a length of 44.0 mm., and a width of 23.0 mm. The body-wall of this region is very spongy in texture, being made up almost entirely of the felted mass of gland-tubules, the actual integument being quite thin in this location.

The external renal opening is a minute inconspicuous pore, situated below and near the posterior end of the base of the ctenidium.

Shell.— The shell (Plate 4, fig. 2) is moderately large and strong, hatchet shaped, with a deep posterior sinus. The dorsal cuticular portion is well developed and of a light amber color. The calcareous portion was somewhat broken, so that the exact limits of its extent forward and toward the right or younger margin could not be determined accurately. The spire is loosely coiled and heavily calloused and rough. Along the back the margin is rather broadly reflexed posteriorly, becoming narrower in front and disappearing before the anterior end of the shell is reached. Toward the apex this reflexed margin broadens and is continued into the apical calloused area. The margin of the sinus is similarly, but more narrowly reflexed. The shell is 54.0 mm. in extreme length by 31.0 mm. in width, with an approximate altitude of 6.0 mm.

INTERNAL ANATOMY.

Owing to the lack of material a complete description of the anatomy of *Dolabella agassizi* cannot here be given, the more important systems alone having been studied.

Alimentary tract.— The specimen was dissected from below, a mid-ventral longitudinal incision being carried the full length of the foot. The sole of the foot is strong and muscular, reaching a thickness of 3.0 mm. in front and thinning away behind to 2.0 mm. The inner surface of the pseudo-peritoneum is greenish black in color.

The retractor muscles of the head-region are very strongly developed in the form of a series of broad bands, arranged in the form of an incomplete cone, being absent on the ventral side alone. They arise in the posterior portion of the body-cavity at varying distances from the posterior disc-region, and are inserted at the anterior end in the zone between the rhinophores and the anterior tentacles. It is by the powerful contraction of this group of muscles that the complete inversion of the head-region is brought about.

Pharyngeal bulb.— The relatively small pharyngeal bulb is nearly cylindrical in form, 18.5 mm. long by 14.3 mm. broad and about the same in height. The dorsal, ventral, and lateral faces of the bulb are slightly flattened. Anteriorly it receives the short and broad mouth-tube, and posteriorly it continues into the wide oesophagus, nearly equal in diameter to the bulb itself, a slight external ventro-lateral constriction marking the passage of the one into the other, the slightly yellowish color of the bulb giving way to the bluish gray tone of the oesophagus.

In the specimen at hand the complete introversion of the head-region, extending back beyond the rhinophores, makes the arrangement of the muscles of that region not evident at first sight. The strong retractors of the bulb arise close to the union of the mouth-tube with the body-wall, and are scarcely to be distinguished from the general system of retractors of the whole head-region, their insertion being the same, save for a single pair of dorsal retractors, which are inserted above the bulb.

From the ventral face of the pharyngeal bulb a series of short narrow flat muscles arise, which pass forward and are inserted into the anterior end of the foot. Four of these inferior protractor muscles are found upon either side

of the median line, and they are all of nearly equal size, narrowing from a broad origin to about 0.7 mm. in diameter.

From the dorsal surface of the bulb arises a strong pair of muscles, the superior protractor muscles which diverge forward and outward to their insertion in the antero-dorsal body-wall, above the mouth.

From the postero-lateral face of the bulb arise the long slender dorso-lateral protractor muscles. These are formed on either side by the union of a broad system of superficial muscles from the postero-lateral region of the pharyngeal bulb into a narrow band, which passes upward and forward to an insertion in the body-wall at the side of the mouth.

From a deep origin slightly in front of the middle of the bulb arise the very strong paired ventro-lateral protractor muscles. They pass upward, forward, and outward to the antero-lateral body-wall.

Plate 8, fig. 5, illustrates the arrangement of the internal structures of the pharyngeal bulb as seen in a dorsal view. The bulb has been slit longitudinally in the median line and the sides reflected. Guarding the opening at the anterior end is the pair of lateral mandibles, *m*, behind these in the median line is the large radula, and on the roof of the cavity, above and behind the radula are the spinous palatal folds, *l. f.* The structure of each of these will be taken up in detail.

Mandibles.— The amber colored mandibles are in the form of two strong triangular plates on the sides of the mouth-opening. They measure 7.5 mm. in height and 4.0 mm. in greatest width. The broader basal portions are wide apart, being separated by fully 7.6 mm. while the apices nearly meet in the median line above. Plate 8, fig. 4, exhibits the relations of the mandibles in *D. hasseltii* as seen in a transverse section of the pharyngeal bulb. The plane of the section passes somewhat behind the tip of the mandibles, in about the region indicated by the dotted line *m*, (Plate 8, fig. 5). This causes the tips of the mandibles to seem much more separated than they really are. The anterior edge of each mandible is frayed and broken through use, while the posterior border disappears in a deep sulcus of the wall, in which the mandible is developed. This is shown at *g* Plate 8, fig. 4, and in detail Plate 7, fig. 1. The cuticle (Plate 8, fig. 4) is everywhere much thicker than the underlying epithelium which produced it, as shown by the narrow shaded basal band, representing the latter, in comparison with the clearer strip above it. In the region of the mandible the cuticle becomes much increased in thickness and is differentiated into rodlets. These are closely packed structures of a slightly

compressed prismatic form, their distal ends appearing usually as somewhat elongated polygons when seen in surface view, (Plate 8, fig. 7). Here *a* represents the younger region of the mandible, toward the bottom of the sulcus, while *b* is toward the outer or older border. The rodlets are longest near the middle of the mandible and are shortest at the bottom of the groove or sulcus in which they are produced (Plate 7, fig. 1). The distal end of each rodlet is terminated by a strong oblique cap, the anterior edge of which tends to overlap the next one in front of it. Each rodlet tapers somewhat toward its proximal or basal end and rests upon a single epithelial cell in the posterior half of the mandible, of which it is plainly a cuticular differentiation. The development of these rodlets may be followed in fig. 1 and 2 of Plate 7. The whole pharyngeal cavity is lined by a single layer of columnar epithelial cells, bearing a cuticle of varying thickness. At the posterior margin of the mandible this epithelium is invaginated into a deep sulcus, as before described, the innermost portion of which is slightly inrolled forward (Plate 7, fig. 1 *c*., fig. 2). The cells forming the floor of this groove secrete the mandibular rodlets, a single one being produced by each cell. At the bottom of the sulcus the rodlets are shortest and youngest, appearing as a thin light yellow cuticular layer. New layers are added beneath this outermost deposit successively, and various stages in the growth of the rodlet may be met with in series toward the front. About midway of the width of the whole of the mandible the rod-forming cells cease the production of these layers, and take on the formation of a common basal cuticular secretion, upon which the anterior rodlets are borne (Plate 7, fig. 1, *b*). This homogeneous substance first appears as a narrow band between the epithelial cell and its rodlet, and increases progressively in thickness toward the anterior border. Beyond the mandible it continues as the common thick cuticular lining of the mouth-tube, homogeneous save for slight indications of stratification parallel to the basal epithelium. The maximum length of the rodlets is thus reached about midway of the width of the mandible, and the progressive shortening seen from that region forward is evidently due to the wearing away of their distal ends, until the rodlet itself finally breaks away and disappears, as at *a*, Plate 7, fig. 1. While this is taking place along the floor of the mandibular sulcus the epithelium forming its upper wall or roof is secreting a continuous mass of chitin (Plate 7, figs. 1, 2, *d*) which fills up the remainder of the space above the rodlets. This upper layer is faintly striated and extends well forward beyond the edge of the sulcus, gradually thinning away as the region of the anterior margin of the mandible is approached. Thus

only the most anterior of the rodlets are exposed to the attrition of use, the remainder being covered by the projecting layer of cuticle.

Under a high magnification the innermost portion of the mandibular sulcus is shown in fig. 2, Plate 7, and merits somewhat closer examination. The epithelial cells, *e*, are of a high columnar form, and each one bears upon its distal end a single rodlet, in successively later stages of formation from the bottom of the groove outward. The distal end of the cell is nearly flat or but slightly convex while the first layers of chitin (conchin) are produced, but becomes more arched in the later stages, until it reaches a high conical form, as shown at the right side of the figure. The corresponding layers of each rodlet are similarly arched, the outermost ones but slightly, while those more recently formed are more and more curved. The margin of each successive layer forms a ridge upon the surface of the rodlet, as is more clearly seen in fig. 3 and 4 of Plate 7, in which a fully formed rodlet with its basal cell is contrasted with a much younger one. The volume of the basal cell in the older stage is very strikingly less than that of those in the earlier stages. The nuclei of these basal cells, or rhabdoblasts, are large, oval in outline, and deeply staining, with many irregular chromatin granules. The cell-protoplasm is longitudinally fibrillated, a great complex of fine fibrillae being readily made out, extending throughout the cell and continuous, indeed, through the substance of the rodlet itself. This is shown (Plate 8, fig. 3*a*), in three basal cells from the younger portion of the mandible. But two layers of the rodlet have here been laid down, and the fine fibrillae of the cytoplasm may be followed out into them for varying distances. The same may be noted, Plate 8, fig. 1, in a group of seven basal cells from an older portion of the mandible, only the innermost part of their rodlets being shown.

Plate 7, fig. 2, and Plate 8, fig. 1, 3, also show the strikingly intimate manner in which the ends of the underlying muscle-fibres are related to the epithelium of the mandible. Immediately below the epithelium is a strongly developed faintly striated layer of compact connective-tissue, with scattered cells, and below this the connective-tissue is more loosely arranged. Numerous smooth muscle-fibres pass up through this compact layer, branching in it and continuing up among the epithelial cells, where they ramify still more, and terminate in close contact with the bases of these cells. In fig. 3 of Plate 8 two such muscle-fibres are represented, penetrating and branching in the connective-tissue layer *f*, and from thence ramifying between the bases of the epithelial cells *e*. Since the figure was drawn with a minimum change of focus,

many of the finer terminations pass out of the plane of vision. In fig. 1, Plate 8, two groups of muscle-fibres *b*, *b*, terminate in the same manner. Here also a change of focus shows that the interlacing feltwork of the fine branches is even more extensive than here shown. So far as this material permits conclusions to be drawn there exists a continuity of the finest prolongations of the muscle-fibres with the epithelium-cells. An actual continuity of the myofibrillae with epithelial fibrillae, such as described by Brück (1813) for Anodonta and Cyclas, and by many other writers for arthropods, could not be satisfactorily established, though there is much to favor its existence.

Radula.— Immediately behind the mandibles lies the large and strong deep amber radula. *In situ* its exposed surface presents a conventional heart-shape, as seen from above, the anterior narrower end being abruptly rounded and continued downward into a deep groove in front and laterally. The dorsal groove of the radula is deepest behind, and extends forward two thirds the length of the organ, becoming shallower in front, while behind it merges into a transverse groove. The highest portions of the radula thus form the sides of the median groove, and round over toward the sides and more abruptly in front. The rows of functional teeth curve around over this elevated surface, in general parallel to its external contour, Plate 8, fig. 5. Deep in the median groove the youngest teeth are covered with the epithelium of the sheath. When freed from its attachments, cleaned, and flattened out, the shape of the radula is approximately rectangular, the sides being nearly parallel, the posterior border nearly straight, while the anterior margin is bluntly pointed. In extreme width it measures ca. 18.4 mm., in median length, 14.3 mm., while the sides are 11.8 mm. long.

The teeth are arranged in sixty-two transverse rows, the first four of which are incomplete, worn, and broken. Succeeding these are thirty-six rows which are exposed and functional, and then twenty-four rows which are still inclosed within the radula-sheath. The number of teeth in each half row varies, increasing from before backward from 170 in the eighth, and 198 in the twenty fifth to a maximum of 230 in the forty second row. The dental formula of *Dolabella agassizi* may hence be given as $62 \times 198\text{–}230 \cdot 1 \cdot 198\text{–}230$, there being a single median tooth in each row, and the total number of teeth probably being not far from 25,000.

The median tooth is but little more than an elongated slightly flattened rudiment in the first twelve rows of the radula (Plate 6, fig. 3, 4). Further back it develops a transverse club-like anterior thickening, the tip being curved

upward, with a thinner median prolongation shading off into the flattened posterior end of the tooth (Plate 6, fig. 6–8). Occasionally an evidence of a short bluntly pointed compressed median hook appears at the anterior end, (Plate 6, fig. 9) which represents the median tooth from the fifty ninth row, but no lateral denticulations, such as those figured by Bergh (1905) for *D. rumphii* [= *scapula*] are to be found. The structure is likewise much simpler than that found by Mazzarelli and Zuccardi (1890) in *D. hasseltii*, *D. teremidi*, and *D. tongana* [= *ecaudata*], and by Farran (1905) in *D. scapula*, the only other species of Dolabella whose radulas have been described and figured. In length the median tooth ranges from 0.192 mm. to 0.210 mm., in width at the anterior end 0.012 mm. to 0.018 mm., at the posterior end from 0.063 mm. to 0.084 mm.

The lateral teeth are simple strongly compressed hooks borne vertically upon the surface of the radula-membrane. In general they differ but little in size and form, the first three or four inner laterals being slightly smaller than the remainder, while the outermost four or five decrease rapidly in size. A typical lateral tooth from the posterior portion of the radula is shown in side view in Plate 6, fig. 2. The base, *a–b*, is straight and narrow, averaging 0.246 mm. in length, and 0.012 mm. in maximum width. Its posterior end, *b*, slopes rapidly downward to the surface of the cuticular membrane, to which the teeth are attached. From the anterior end rises the strong but narrow hook, *a–c*, its anterior margin thickened and supported behind by a thinner median part. The tip is blunt and rounded, though occasionally slightly bifid tips may be found. The vertical height of the hook above the bottom base line averages 0.336 mm., and its thickness is the same as that of the base, 0.012 mm. Here and there abnormal teeth may be seen, apparently formed by the fusion of two normal ones, the united hooks being more or less separated toward the tips. Such an abnormal form is usually repeated at the same point in successive rows of the radula throughout the whole or the greater portion of its extent, being caused by some malformation of a definite group of odontoblast cells at the bottom of the radula-sheath, each successive tooth produced by them being similarly deformed. An instance of this (Plate 5, fig. 3) represents the four innermost teeth of the thirtieth row. The hook of the fourth of these worn teeth is broad and deeply bifid, as is also the base. Four teeth from the corresponding position in the fifty sixth row are given in Plate 5, fig. 5. The same bifid condition is found in the fourth tooth here, the division of the hook, however, being nearly complete. These teeth are from within the radula-sheath and have not yet been exposed to wear, though the tip of the innermost one has

been broken off accidentally. In all the other rows of the radula this malformed tooth appears in a corresponding position to those here figured.

Our information respecting the dentition of the Dolabellinae is very meagre, being limited to a paper by Mazzarelli and Zuccardi (1890), one by Eliot (1899), one by Farran (1905), two by Bergh (1905, 1907), one by Vayssière (1906) and the figures given by Pilsbry in Tryon's Manual, **16**, Plate 67, fig. 17, 18. In these papers the radulas of five species are described of the fifteen or twenty more or less doubtful species which have been recorded. In general a uniform type of dentition prevails, the number of rows and the number of teeth in each row being indefinite, and varying with the size and age of the animal. The dental formula of *D. scapula*, for example, ranges from 44 × 120–1–120 (Farran) to 45–60 × 120–160–1–120–160 (Vayssière), and 60 × 200–1–200 (Bergh). The formula for *D. agassizi* is at present the highest recorded, being 62 × 198–230–1–198–230. Nor are any striking differences to be found in the form and size of the individual teeth in these species. The median one is small and inconspicuous, with its hook small, rudimentary, or absent (*D. californica*). Eliot states that the median tooth is entirely wanting in *D. hasseltii* from Samoa, but in my serial sections of the pharyngeal bulb of a specimen of this species from the same locality I have no difficulty in recognizing it as a flattened plate bearing a small hook, so his observation is probably erroneous. Nor do I find any such complicated forms of teeth as those figured by Mazzarelli and Zuccardi (1890, tav. 1, fig. 16, 18–20), and am inclined to question their interpretation of the microscopic appearance of the teeth, which, as is well known, is often by no means an easy matter. The statement of Bergh that the median hook of *D. scapula* is finely denticulate is not confirmed by Vayssière nor by Farran. The lateral teeth are uniformly simple compressed hooks of regular form and of fairly uniform size, the dentition as a whole thus differing widely from the type characteristic of all other genera of the Aplysiidae, in which strongly developed median and lateral teeth with complicated denticulations are found in every species. With what this striking difference may be correlated is not evident, in the lack of any information as to food, habits, etc.

Palatal folds.— The postero-dorsal region of the pharyngeal bulb, directly overlying the radula, bears a pair of flap-like reduplications of the dorsal wall, which project obliquely downward and backward into the cavity (Plate **8**, fig. 5, *l. f.*). These folds are of an elongated triangular form, the pointed apex being directed forward, while the posterior free end is rounded and lobe-like. They are continuous with the dorsal wall of the bulb along their outer margins,

the inner free ones are thick and fleshy and nearly meet each other in the median plane. Thus they form the incomplete floor of a dorsal space, of a more or less elongated triangular form, limited behind by a low transverse ridge (Plate 8, fig. 5, *f*), which unites the posterior ends of the palatal folds across the median line, though communicating freely with the oesophagus beyond. This space is the "doccia faringea" of Zuccardi (1890) or pharyngeal groove, and is considered as a prolongation of the dorsal portion of the oesophagus, the palatal folds being his "creste pharynge," or pharyngeal crests. It communicates freely with the cavity above the radula and loses its identity as a separate groove before reaching the region of the upper ends of the mandibles, contrary to the observations of Zuccardi in the Neapolitan Aplysiidae. Into the anterior portion of this space the ducts of the long strap-like salivary glands open.

Palatal spines.— Each of these palatal folds bears thickly set tapering spines on its ventral surface, their tips being directed obliquely backward. The tips are brown or of a deep amber color, while the main portion of the shafts is lighter amber or whitish. The spines are quite flexible, readily bending on pressure with a needle. In length they range from 0.24 mm. to 0.5 mm., with a basal diameter reaching 0.096 mm. as a maximum. They are gently tapering throughout their extent, with the tip abruptly curved backward, as shown in Plate 9, fig. 1, S. The surface of each spine is obliquely ridged by a series of parallel elevations, corresponding to strata of growth which extend through its whole thickness. The lower one half to two thirds of the spine bears a moderate, shallow groove upon its posterior surface (Plate 9, fig. 1). Toward the posterior border of the palatal fold the spines become more slender and filiform (Plate 10, fig. 9). All the palatal spines are imbedded in a thick chitinous or cuticular matrix, from which the distal ends of the longer spines alone project. In a surface view of a total preparation, isolated with KOH, this matrix is so clear and transparent that it is readily overlooked, the spines appearing entirely free save at their bases, but in transverse sections, as in Plate 9, fig. 7, *b.*, its presence and true nature is evident. Beneath this general cuticular layer is situated a high columnar epithelium of slender cells which secrete it. The nuclei are small, contain fine chromatin granules scattered on a delicate linin network, and are situated in the basal half of the cell. The distal half is filled with fine granules, extending down to the zone occupied by the nuclei. Near the anterior border of the palatal flap these granules are especially numerous, and frequent evidence of a discharge of a homogeneous secretion from the cells into the cuticle is seen, Plate 10, fig. 7. This secretion is most marked in the

lower layers of the cuticle, and gradually decreases, and becomes blended with the strata toward the middle and upper portions. In the outer layers the cuticle appears entirely homogeneous, save for the indications of the successive parallel layers of deposition from the epithelial cells.

At intervals among these smaller epithelial cells single gigantic ones are to be found, each of which lies at the base of a palatal spine, and apparently produces it (Plate 9, fig. 8, *b*). These cells are usually found at the bottom of slight depressions below the general level of the epithelium. This matrix-cell often reaches a diameter of 0.10 mm. in width by 0.04 mm. in height, extending the full width of the base of the overlying spine (Plate 9, fig. 3). The bulk of the cell is finely granular, the upper portion, however, is often more coarsely so, and is sometimes very vaguely limited, being broken up into a mass of rounded granules of irregular size, underlying the base of the spine, the whole appearance strikingly suggestive of poor fixation, which is very probably the case.

The very large somewhat flattened spheroidal nucleus occupies the basal region of the cell, lying close to the basement-membrane. It contains clearly defined chromatin granules, and one or two nucleoli. The basal portion of the cell frequently bulges downward below the general level of the epithelium and not infrequently extends below the bases of the adjoining cells as in Plate 9, fig. 3. In some cases it somewhat resembles a large nerve-cell, but careful study fails to reveal any trace of a nerve-fibre proceeding either from or to it. In some sections, near the margin of the base of a spine, such cells appear to be subepithelial in position, as is seen in Plate 9, fig. 3, in the large cell adjoining the matrix-cell of the spine. This is, however, the matrix-cell of an adjoining spine not shown in the figure.

All stages of the development of these palatal spines may be found scattered irregularly in sections, as each spine passes through its developmental history irrespective of its neighbors. One of the earliest stages is shown in Plate 9, fig. 2. The finely granular matrix-cell is smaller than in later stages, but is much larger than the adjacent ones. Upon its distal end, which arches above the general level of the surrounding epithelium, is borne a thin cap of a highly refractive substance, the beginning of the young spine. In Plate 9, fig. 4, the matrix-cell has much increased in size, and its chitinous cap has already become so thickened that its substance appears in two layers. The apex of the spine is already outlined by the oblique growth of the first strata. In Plate 9, fig. 5, 6 further stages in development are shown, and they could be readily

multiplied. In Plate 9, fig. 8, the spine has reached nearly its full size, but is imbedded so deep in the common cuticula that its apex is some distance below the free surface. In fact but very few spines retain their connection with the basal matrix-cell when the wearing away of the general surface exposes their tips. When each spine reaches a length of approximately 0.5 mm. the further deposition of basal layers by the matrix-cell ceases, and the spine becomes separated from it and is simply imbedded in the surrounding cuticle. The continual formation of the cuticle below and its erosion above brings the tip of the spine to the surface and successively the remaining portions (Plate 9, fig. 7), the spines being evidently harder and more resistant than the cuticle surrounding them. The base of the spine is carried farther and farther away from the epithelium by the continued formation of new layers of the general cuticle, while its upper portion is progressively more and more exposed above, finally becoming entirely free, and falling away. The basal cell appears to enter upon the formation of a new spine in a short time, as frequent instances are found in which a very young spine is in process of development immediately beneath the base of a mature one, which has evidently been produced by the same matrix-cell.

This relation of the palatal spines to the epithelium and to the common cuticle is shown in Plate 9, fig. 7, under low magnification. The free ends of the spines here are relatively few in number in the thin section, while others are seen at various levels. This appearance is not due to any obliquity of the section, as might be readily supposed. The plane of the section is nearly transverse to the long axis of the fold, *c* is its free margin, *a* its dorsal surface, and *b* its ventral one. At *e* there is found the typical thickness of the cuticle of the general lining of the buccal cavity. It increases very rapidly on the ventral surface of the palatal fold, but abruptly thins away to a very thin layer at the free margin. In this region a deep gland-like infolding of the epithelium occurs in all the sections, characterized by the presence of a very great number of large unicellular gland-cells extending down below the basement-membrane. Similar cells are found continuing around the free margin and over the dorsal surface of the fold. One of these gland-cells is shown in Plate 8, fig. 2. Here the epithelium had been stripped away accidentally, so that the apex *a*, showing the secretion discharge from the cell, appears at the level of the basement-membrane *d*. The nucleus of the cell is not contained in this section, but is relatively poor in chromatin. The cytoplasm in the lower proximal portion of the cell shows a fine reticulum with deeply staining nodal granules. These gradually

merge into the zone *b*, in which the homogeneous secretion increases in amount and staining quality, appearing almost black with hematoxylin at the point of discharge, *a*. In other sections this secretion, evidently of a mucous nature, is seen issuing between the epithelium-cells, and is especially abundant in the deeply infolded groove shown in Plate 9, fig. 7, near the free margin of the flap. Here the secretion accumulates in considerable amount, and issues between the thick cuticle of the spine-bearing area and the epithelium just beyond it.

Other very characteristic gland-cells are scattered just below the epithelium of the dorsal surface of the fold. Many of these show no connection with the surface, while others are united by more or less slender neck-like prolongations. A group of these cells is shown, Plate 8, fig. 6. Deeply staining nodal granulations of varying size and shape are abundant in them. Unfortunately the fixation of the limited amount of material at hand does not permit any trustworthy conclusions to be drawn concerning them.

The epithelium of the palatal folds rests upon a narrow layer of dense connective-tissue, below which are found bundles of smooth muscle-fibres, running at various angles, and surrounded by a large amount of fibrous connective-tissue. The central area of the fold is occupied by looser connective-tissue, in which scattered bundles of longitudinal muscle-fibres are located. At the base of the section, Plate 9, fig. 7, is shown the duct of the salivary gland in cross-section at *d*.

In *Dolabella hasseltii* (Fér.) similar relations of the palatal spines to the epithelium and the cuticle were made out, with some differences worthy of note. In this form the spines are slender, thick-walled, tapering tubes, the thickness of the walls increasing and decreasing at regular intervals in coincidence with a system of parallel ridges and depressions of the outer surface. Each spine is the product of a single matrix-cell, the central free end of which is prolonged into the tubular base of the spine, while the wall itself is secreted by the zone of the cell-surface around this projection. Thus the spine fits down over the prolonged tip of the cell in the form of a conical cap, the successive layers of chitinous substance being in the main secreted by the sides of the distal end. The central portion, however, takes part in this secretion at intervals, the layers then formed appearing as several curved dome-like sheets, bridging across the entire lumen of the spine and continuing downward as part of its sides. No indication of the participation of any of the surrounding cells in this secretion could be found, nor is anything here present similar to the small central cell which determines the cavity in the spicule-development in the Solenogastres, as described by Heath (1911, p. 28).

In *D. agassizi* the palatal spines are entirely solid structures, save at the extreme base, where a slight depression exists, so that, while the general external form and surface-configuration is very much the same as that in *D. hasseltii*, the internal structure as seen in sections is strikingly different. The presence of palatal spines has been indicated in many of the Aplysiidae but in no case have any details been given concerning their development or structural relations. Bergh (1905, 1907) briefly describes their form and figures them for *Dolabella rumphii* [= *scapula*], this being the only reference to them in this genus.

Immediately behind the radula, on the floor of the pharyngeal bulb was found a small area of spines similar in form to the palatal ones. They are borne at the summit of a transverse crescentic fold, highest in the median line, which measures 2.0 mm. in length by slightly more in width. In the unopened tube this area would be situated just below the posterior free ends of the palatal folds and immediately behind the median groove of the radula. Unfortunately the epithelium of this region was somewhat macerated, so that further details could not be made out.

Salivary glands.— The salivary glands have the long strap-shape common in the family. They enter the bulb upon the posterior dorsal surface, the duct continuing forward near the base of the palatal folds, as shown in Plate 9, fig. 7, *d*, and opening into the cavity above the anterior portion of the radula. The posterior end of the right salivary gland loops across below the oesophagus, its tip being attached to the wall of the proventriculus, immediately in front of the masticatory stomach. The tip of the left salivary gland is similarly inserted upon the opposite side, the relations being the same as in Tethys (MacFarland, 1909).

Oesophagus.— The thick-walled oesophagus, succeeding the pharyngeal bulb is relatively short, measuring some 56.0 mm. in total length. At first it is large and roomy, ranging in diameter from 12.0 mm. just behind the bulb to 17.0 mm. at a distance of 27.0 mm. beyond it. From this point the oesophagus rapidly narrows as it passes upward and to the right, reaching its minimum diameter of 7.0 mm. just before it suddenly dilates into the proventriculus. Its mucous lining is thrown into some ten well-defined longitudinal folds, from the sides of which numerous minute and short secondary ones arise but quickly die away. The main longitudinal folds cease abruptly at the entrance of the oesophagus into the first division of the gastric apparatus, the proventriculus, or ingluvies.

Ingluvies and triturating stomach.— The ingluvies is thin-walled and rela-

tively small, much less than Tethys in its proportionate dimensions. The second, or triturating stomach lies upon the left anterior face of the posterior visceral mass, its long axis being directed downward, inward, and forward, and opening into the large saccular third gastric division. The second stomach has a thick glistening yellowish muscular wall, and is cylindrical in form, measuring 14.0 mm. in length by 22.0 mm. in diameter. Upon its inner surface are borne several rows of large strong horny teeth, which nearly close the lumen as they meet in the centre. They are readily detached from the plate-like elevations of the wall bearing them. Plate 10, fig. 1 illustrates in an outline drawing the relative size and position of these areas, the stomach having been slit lengthwise and opened out flat, and the teeth being all removed; *a* is the posterior end of the oesophagus, *b*, the ingluvies, or first stomach, *c* the thick-walled second stomach, and *d*, the roomy third division.

The largest teeth of this first grinding stomach are of a dark amber color and have the approximate form of a four-sided pyramid, the very convex base rhomboidal in outline, the sides somewhat concave, and the blunt irregular apex almost directly above the middle of the base (Plate 10, fig. 5). These largest teeth reach a height of 10.5 mm. with basal dimensions nearly the same, and are borne in a circle midway of the organ.

Behind these and alternating with them is a single row of medium sized teeth and in front of them two more rows, the nearest of medium size, the most anterior quite small. The teeth of medium size are of the same color and shape as the largest ones, though often more compressed laterally (Plate 10, fig. 2, *a* and *b*, fig. 8, 10). About nine teeth make up this group, and they pass over into that of the smaller size, in which the tooth is strongly compressed and becomes somewhat wedge-shaped (Plate 10, fig. 4, *a* and *b*). The tallest central part of such a tooth is occupied by a slightly curved axial portion of a lighter color, in which the parallel lines of growth are strongly marked. This flattened shaft extends upward from the middle of the base and forms the cusp of the tooth at its apex, and appears as if imbedded in the remainder of the chitin, especially when viewed as a transparent object. The basal length of the largest tooth of this type is 6.0 mm., its height 6.5 mm. and its width 4.0 mm.

The smallest teeth form a fourth type in shape, that of a slender conical spine, (Plate 10, fig. 3). Several of these are found in the anterior row of the second triturating stomach, but they are more characteristic of the third gastric division (Plate 10, fig. 1, *d*). Here they are smaller (Plate 10, fig. 6), and very abundant, being scattered closely over the whole inner lining. Each of these

small spines is also borne on a slightly raised and thickened disc, but they are so inconspicuous that they are not represented in Plate 10, fig. 1.

Liver and intestine.— The posterior visceral mass, made up of the remaining portions of the alimentary tract and the ovotestis, occupies nearly the whole of the body-cavity behind the head. Its ventral surface is convex, rounded behind and in front, the black liver contrasting strongly with the light yellow intestine and the reproductive gland. The dorsal surface is deeply faceted with irregular depressions, caused by the pressure of the overlying organs, notably those of the reproductive system.

At the posterior end of the third stomach, a series of low ridges in its inner layers converge toward the opening of the intestine. This portion of the digestive tract is imbedded in the liver, occupying a deep groove in its surface. The intestine passes into the right side of the liver, curving downward to its ventral surface, across which it passes to the left anterior margin, thence up to the dorsal surface, across which it passes obliquely backward, thence downward again in a loop upon the posterior surface between the liver and the ovotestis, returning after describing this curve to the right ventral side, whence it passes upward and backward to the anal opening at the base of the siphon. It thus forms in general a wide loop from below upon the left and dorsal surfaces, a disposition corresponding closely to that found in Tethys. The total length of the intestine is *circa* 300 mm., and its average diameter 7.0 mm.

At the posterior end of the third stomach, below and to the left of the pylorus, a spacious biliary cavity opens into it by a large channel. Into this cavity in turn open numerous bile-ducts, which ramify out into the poorly defined lobes of the liver. From the left of the biliary chamber the strongly curved hepatic caecum extends, approximately 25.0 mm. in length. Owing to the softened condition of the inner walls of this region the longitudinal folds dividing the lumen of the caecum and their relations to the biliary chamber and the intestine could not be made out clearly, but they appeared to be substantially the same as in Tethys (MacFarland, 1909, p. 44).

The whole alimentary canal, with the exception of the oesophagus, was quite uniformly distended with coarse detritus of an algal nature, mixed with considerable sand. In the intestine the latter was especially abundant, the organ being crowded full with it.

Reproductive System.— The reproductive system of Dolabella is composed of the following parts, which will be described in the order given.

1. Ovotestis.

2. Small hermaphroditic duct.

3. Adnexed genital complex, consisting of the nidamental and albumen glands, the fertilization-chamber, and the convoluted and spiral portions of the genital duct.

4. Spermatocyst and duct of Cuvier.

5. Large hermaphroditic duct, made up of the ovospermatic and the copulatory ducts.

6. Spermatotheca and its duct.

7. External spermatic groove.

8. Penis and its sheath.

Ovotestis.— The ovotestis occupies the posterior end of the body-cavity, in close contact with the liver in front and the body-walls elsewhere. In consequence its anterior face is irregularly faceted from the pressure of the liver and of the loops of the small hermaphroditic duct and the adnexed genital complex. The remainder of its surface is convex, conforming with the contour of the body-walls, its general form being nearly hemispherical. Its extreme antero-posterior length is ca. 23.0 mm., its diameter 35.0 mm. The yellowish gray color of the ovotestis contrasts strongly with the uniform black of the liver in contact with it.

Plate 5, fig. 4 represents the main portions of the reproductive apparatus, as seen from below, that view revealing the relations of its parts best, with but a minimum amount of displacement. The ovotestis and the penis are not shown in this figure.

Small hermaphroditic duct.— From the upper right surface of the ovotestis the yellowish white small hermaphroditic duct (Plate 5, fig. 4, *sm. h.d.*), arises, the loops of its many closely coiled windings resting upon the upper anterior surface of the gland. The approximate length of the duct is at least 65.0 mm., though its hardened condition made the measurement difficult. Its diameter averages about 3.0 mm. The general course of the duct is obliquely forward and to the right, joining the very large adnexed genital complex at its right posterior angle.

Adnexed genital mass.— The dark yellowish brown adnexed genital mass (Plate 5, fig. 4, *a. g. m.*) is strikingly large, nearly reaching the bulk of the ovotestis. In form it is irregularly prismatic, flattened somewhat dorso-ventrally and elongated laterally. It is placed transversely in the posterior dorsal region of the body-cavity, its thicker portion at the left, resting in a deep groove upon the postero-dorsal surface of the liver, and between it and the ovotestis, and is closely bound to the dorsal body-wall by connective-tissue.

Its extreme length, transverse to the longitudinal axis of the animal is 40.0 mm., its greatest antero-posterior width is 20.0 mm., while the thickness of its bulkier portion on the left reaches 14.5 mm., thinning away toward the right to some 7.0 mm. The dorsal surface is somewhat regularly convex, the ventral one quite irregular, but in general concave, as are also the anterior and posterior borders. The main bulk of this structure is made up of the nidamental and albumen glands, the windings of which are closely interlocked in the one common mass. An examination of Plate 5, fig. 4 will show its main relations. The small hermaphroditic duct, *sm. h. d*, reaches the right posterior angle of the adnexed genital mass, tapers rapidly to a third of its previous diameter, and passes diagonally across the lower surface to its mid-anterior margin. Here it curves around upon the dorsal face, forms there a broad loop and returns upon the ventral surface, *sm. h. d'*, to its posterior portion. Here the duct opens into a small irregular cavity, the fertilization-chamber, *f. c*, lying deep between the loops of the nidamental gland.

Spermatocyst.— Into the same cavity opens the duct of Cuvier, *d. C*, or duct of the spermatocyst. This organ, *spc.*, lies in close contact with the anterior border of the anterior genital complex, to which it is bound by delicate connective-tissue. It is of elongated cylindrical form with its blind end recurved upon itself, and is shown in Plate 5, fig. 4 dissected free and raised slightly from its close attachment.

Immediately at the union of the duct of the spermatocyst with the fertilization-chamber is found the opening of the copulatory duct, *c. d.* This duct is continued to the right, uniting with the ovo-spermatic duct, *ov. sp. d*, to become the left half of the large hermaphroditic duct, *l. h. d.*

Albumen and nidamental glands.— Into the fertilization-chamber also open the duct of the albumen gland, and the proximal continuation of the spiral and convoluted portions of the ovo-spermatic duct, *ov. sp. d.* By a complicated plication of the walls of this duct the massive nidamental gland is formed, which makes up the bulk of the adnexed genital mass.

Large hermaphroditic duct.— After the union of the copulatory and the ovo-spermatic ducts they leave the right posterior border of the adnexed genital complex and continue forward in a complicated series of loops as the large hermaphroditic duct, *l. h. d.* A section across this structure shows that the two ducts involved in it form simply the left and right halves respectively of a single tube, separated from each other by thick folds from the dorsal and ventral sides, which meet and interlock in the centre, thus dividing the lumen into two nearly separate ducts.

Spermatotheca.— At the distal end of the large hermaphroditic duct, just before it opens externally, it receives the duct of the spermatotheca, *sp. th.*, and also dilates anteriorly into a blind sac, the seminal receptacle, *r. s.* The spermatotheca is a large pear-shaped sac, with thin walls, lying close in front of the adnexed genital complex. Its slender duct is given off from the left side, passes backward and to the right, closely attached to the dorsal wall of the body, and opens into the left side of the large hermaphroditic duct, 16.0 mm. before the external opening of the latter is reached. The total length of the duct of the spermatotheca is ca. 26.0 mm., its diameter ranging from 2 to 3 mm. The large seminal receptacle, *r. s*, is strongly developed at the distal end of the large hermaphroditic duct. Its lumen is strongly glandular, the walls being thrown into a considerable number of high longitudinal folds which dwindle away and disappear as the large opening is approached by which the receptacle communicates with the vaginal portion of the copulatory duct.

External spermatic groove and penis.— The common external genital orifice (Plate 4, fig. 3) is located in front of the middle of the ctenidium and directly below it. In Plate 5, fig. 4 its position in relation to the internal reproductive apparatus is indicated by the cut edge of the integument at *i*. It presents two incompletely separated openings, bounded by strongly developed margins. The posterior one of these is that of the vaginal portion of the copulatory duct, the more anterior one, the ovo-spermatic duct is continued forward by the external spermatic groove, at first wide, but rapidly narrowed by its approaching sides (Plate 4, fig. 3, *l. r.*). This ciliated furrow emerges dorsally from the pallial cavity, between the anterior ends of the parapodia (Plate 1, fig. 1), is continued along the median line of the dorsum to just behind the rhinophores, then curves to the right, below the base of the rhinophore of that side and passes obliquely downward and forward along the side of the head to the external opening of the penis-sac, behind and near the base of the right anterior tentacle. This organ is in the form of a blind sac or sheath of the penis, or glans proper, which is borne within at the bottom of its closed proximal end. The sheath is located between the right side of the pharyngeal bulb and the retractor muscles of the head and its proximal end is sharply recurved dorsally. Its total length is ca. 50.0 mm., the diameter varying from 4.0 mm. in the anterior half to 6.0 mm. in the posterior portion. A strong retractor muscle terminates its posterior end, while two broad flat protractor muscles arise along the anterior dorsal and ventral margins of the sheath. The three muscles are inserted in the lateral body-wall. Into the external opening of the sheath the deep spermatic

groove passes, is continued along its inner surface to the base of the penis, and recurves along the latter to its tip. The margins of the groove are formed by two thin and prominent folds of the integument, inclosing a narrow V-shaped furrow between them. Immediately above this groove at the external opening of the penis-sheath a higher and more fleshy fold of its lining projects into its lumen, and extends backward throughout nearly the whole length of the sac, becoming lower and less conspicuous from the middle of its length backward. Numerous other lower, smaller, and more irregular folds may also be traced along the lining of the sheath for varying distances. The general color of the epidermis of the organ is a dark brown, or even black, the pigmentation extending back to about 10 mm. of the bottom of the sheath. The penis, or more exactly, the glans-penis proper, is slender, flattened throughout and pointed at the tip. It is 26.5 mm. long and 5.0 mm. wide at its base. Together with the eversible praeputium, or penis-sheath, the whole organ attains a length of 76.0 mm. The color of the glans is uniformly light yellow and it is destitute of any armature whatever.

Nervous System.— But little study seems to have been made upon the nervous system of Dolabella, the allied genera Tethys and Notarchus having fared much better in this respect. Aside from a brief paper without figures by Amaudrut (1886), the studies of Lacaze-Duthiers (1898) upon the buccal ("stomatogastric") ganglia and nerves, and very fragmentary notes by Bergh (1905, 1907), no observations have been recorded upon the nervous apparatus of this form, since the first studies of Cuvier (1804). Lacaze-Duthiers (1898) presents good detailed figures dealing with the distribution of the sympathetic nerves of *Dolabella scapula* in comparison with *Tethys* (*Aplysia*) *depilans*, and Bergh (1905) gives a rough and manifestly incomplete figure of the central ganglia of *D. rumphii* [= *scapula*]. It has, therefore, seemed very desirable to devote considerable attention to these structures in the Easter Island species.

Central nervous system.— The general features of the nervous system of *Dolabella agassizi* are similar to those characteristic of the Aplysiidae in general. Four pairs of large ganglia, the cerebral, pleural, pedal, and buccal are grouped around the posterior end of the pharyngeal bulb. The members of three of these pairs, the cerebral, pedal, and buccal are united above or below the oesophagus by commissures of different lengths, and the cerebral, pedal, and pleural ganglia of each side are united by connectives into the familiar triangular grouping, characteristic of the Gasteropoda in general. In addition to these larger ganglia the parietal and visceral ones are fused into one common mass at

the posterior end of the visceral loop, while other smaller ganglia, such as those of the anterior tentacles and rhinophores are borne at varying distances from the central group.

Cerebral ganglia.— The cerebral ganglia form an extremely flattened circular disc, lying upon the dorsal face of the anterior end of the oesophagus, just as it emerges from the pharyngeal bulb. Since they are not closely united to the underlying digestive tube a certain amount of variation in their position in reference to it may be found in different specimens, as pointed out by Lacaze-Duthiers (1898). They are inclosed in a tough sheet of connective-tissue, which forms a close envelope about them, and is prolonged out upon the nerves, and in a web-like expansion connecting them. Thus the actual size of the ganglia is obscured, but they approximate 30.0 mm. in length and breadth, the thickness being 1.5 mm. in their somewhat shrunken condition. Including the sheath the antero-posterior length is 60.0 mm., the lateral diameter is 70.0 mm. Nothing can be seen of the cerebral commissure, the paired ganglia being completely fused in the median line. Plate 2 represents a dorsal view of the central circumoesophageal group of the nervous system of *D. agassizi*, with the exception of the buccal ganglia, which are shown, Plate 3, fig. 3. The connective-tissue sheaths have been dissected away, and have been omitted entirely from the drawing for the sake of clearness. All of the nerves issuing from the ganglia appear much wider before this sheath is removed, than their actual dimensions warrant.

Cerebral nerves.— In designating the cerebral nerves the endeavor has been made to use the same serial numbering as that employed by Mazzarelli (1893), and by the writer (1909) for *Tethys dactylomela* and *T. cervina*, and to homologize it with that adopted by Amaudrut (1886) for Dolabella, and by Vayssière (1885) for *Notarchus punctatus*. The following tabulation (p. 33) of the cerebral nerves and their distribution in these forms will render a comparison simple.

The first cerebral nerve in Notarchus according to Vayssière, is the cerebro-buccal connective, which is not listed in the above table. In *Dolabella agassizi*, as will be seen by reference to Plate 2, fig. 1, the first and third cerebral nerves are united into a common trunk, *A*, for some distance from the ganglion, while the fifth cerebral nerve arises as two entirely separate trunks, *c. 5a* and *c. 5b*. Other than in these points the cerebral nerves are similar to those of the allied forms given in the table.

The nerve *A* of Plate 2, fig. 1 is the largest of the cerebral nerves of Dolabella. It arises from the anterior border of the ganglionic mass on either side,

Aplysiidae Mazzarelli.	*T. cervina*, *T. dactylomela* MacF.	*D. rumphii* [= *scapula*] Amaudrut.	*Notarchus punctatus* Vayssière.	*D. agassizi* MacF.	Peripheral distribution.
C 1	C 1	4	—	C 1	Integument between tentacles and rhinophores.
C 2 a	C 2 a	5 a	3	C 2 a	Ganglion of anterior tentacles.
C 2 b	C 2 b	5 b		C 2 b	Integument and muscles of mouth-region.
C 3	C 3	1	2	C 3	Ganglion of rhinophores and adjacent integument.
C 4	C 4	2	5	C 4	Optic nerve.
C 5	C 5	6	4	C 5 a	Integument and muscles of mouth-region. On right side a branch to the penis.
				C 5 b	
C 6	C 6	3	6	C 6	Acoustic nerve.

passes outward and forward for about 7.0 mm. and bifurcates into an inner and an outer ramus. The inner of these, *c.* 3, corresponding to the third cerebral nerve of the above table, passes at once through the overlying retractor muscles of the head to its dorsal wall, courses forward between the eyes and penetrates deeply into the integument, giving off a number of fine branches and terminating in the ganglion of the rhinophore, at the base of the latter organ. The outer ramus, *c. 1*, the first cerebral nerve, passes forward within the cone of retractor muscles of the head. On the right side, just beyond its crossing above the superior retractor muscle of the penis-sheath, it receives an anastomosing branch from the third pedal nerve, which recurves posteriorly to it. A short distance toward the cerebral ganglion from this union a branch is given off to the above named muscle, seeming to be a direct continuation of the fibres from the pedal nerve alone. Beyond this point the main trunk of the nerve curves upward and is distributed to the dorsal wall of the head in front of the rhinophores.

Outside of and behind the origin of the nerve-trunk *A*, just described above, arises another nerve but slightly smaller in diameter, the second cerebral nerve. At a short distance from its origin it bifurcates into nearly equal rami, which pass downward and forward along the pharyngeal bulb. The upper of these

two branches, *c 2a*, terminates at the base of the anterior tentacle in a small rounded ganglion, from which numerous delicate nerves ramify to the tentacle itself. The lower ramus, *c 2b*, passes forward, gives off a delicate branch to the lateral protractor muscles of the pharyngeal bulb, and is distributed to the integument of the mouth-region.

Immediately above the origin of the second cerebral nerve on the right side, but above the first cerebral nerve on the opposite one, arises a strong trunk, *c 5a*. This corresponds to a part of the fifth cerebral nerve, its remaining portion, *c 5b*, being included in the same connective-sheath as *c 2*, though with an entirely separate origin. The nerve *c 5a* passes slightly outward, and then straight forward over the pharyngeal bulb, bifurcating after a short course. The more dorsal of its rami, on the right side, gives off a delicate branch at the posterior border of the dorsal rectractor of the penis, which courses forward and ramifies to the body-wall just below the anterior end of the penis-sheath. A second small branch forms an anastomosis with the twig from the first cerebral nerve (possibly, however, coming from the third pedal nerve through the anastomosis of those two previously described, instead) and is distributed to the dorsal protractor muscle of the penis-sheath. The main portion of the dorsal ramus branches to the penis-sheath and to the integument at the side of the mouth. The more ventral ramus of *c 5a* passes directly forward to the integument of the lateral mouth-region.

The remaining portion of the fifth cerebral nerve, *c 5b*, might be considered as a separate part of the second cerebral nerve with equal justification. It is united in the same connective-tissue sheath as the latter, accompanies it in the first part of its course, and is distributed to the integument and muscles of the ventro-anterior insertion of the pharyngeal bulb in the body-wall. This distribution resembles that of the fifth cerebral more than that of the second, which is to the dorsal and dorso-lateral portion of the pharyngeal bulb insertion. Its point of emergence from the cerebral ganglion surface is entirely separate from that of either the second or the fifth nerves, being nearer the fifth on the right side and nearer the second on the left.

From the dorso-lateral surface of the cerebral ganglia, just above the origin of the cerebro-buccal connectives, the slender fourth cerebral, or optic nerve, *c 4*, arises. On the right side it crosses obliquely forward over the base of the fifth cerebral nerve and passes outward, inclosed in the same connective-tissue sheath with it along its inner border, for a short distance, before taking up an independent course. Upon the left side the optic nerve does not cross the base

of the fifth nerve, but runs along its outer border, inclosed in the same sheath for a time. The nerve terminates in the large deep blue eye, which is deeply buried below the surface in the integument, behind the rhinophores. Whether the optic nerve arises from a separate ganglion distinguishable from the cerebral can only be determined by serial sections, which have not been made of this region.

The sixth, or acoustic nerve is extremely delicate and can be traced only with difficulty. It can be made out as originating from the side of the cerebral ganglion close in front of the origin of the cerebro-pedal connective, which it accompanies to the dorsal surface of the pedal ganglion, terminating in the minute otic ganglion and otocyst, both deeply imbedded in the thick connective-tissue capsule which covers the pedal group. It is shown on the right side only in Plate 2, fig. 1, at *c6*, where it reaches the pedal ganglion, but was removed with the connective-tissue capsule on the opposite side. The long cerebro-buccal connectives, *c-b con*, arise from the antero-lateral face of the cerebral ganglia and pass obliquely downward and backward to the buccal ganglia (Plate 3, fig. 3), situated upon the ventro-posterior face of the pharyngeal bulb, immediately below the beginning of the oesophagus.

The cerebro-pedal connectives, *c-p con*, arise from the midlateral face of the cerebral ganglia and are united in a common broad sheath for the most of their extent with the cerebro-pleural connectives, *c-pl con*, which arise behind them from the postero-lateral face of the same ganglia. Together they encircle the pharyngeal bulb in a long course, and unite below with the pedal and the pleural ganglia respectively, as shown in the lower half of the figure. They measure 19.0 mm. in length, being approximately equal in this respect. A short distance from the ventral group of ganglia they separate into two distinct trunks.

Pedal ganglia.— The ventral portion of the circumoesophageal ring is completed by the pedal and the pleural ganglia, represented in dorsal view in the lower half of Plate 2, fig. 1, and in ventral view in Plate 5, fig. 2. The whole complex is united into a single lenticular mass by a thick connective-tissue capsule, which must be carefully dissected away before the relations of the ganglia and nerves may be recognized. In both the figures cited they are represented as entirely free from this sheath. The pedal ganglia are of a flattened elliptical shape, united by a short and broad commissure, 1.3 mm. long by 1.0 mm. broad, and by a slender parapedal commissure, passing below the aorta (Plate 5, fig. 2, *p-p.c*). The two ganglia are of nearly equal size, approximating 2.3 mm. wide by 3.0 mm. long.

Pedal nerves.—Nine pairs of nerves arise from the lateral and posterior margins of the pedal ganglia. They will be described in the order of their occurrence from before backward as numbered in Plate 2, fig. 1, and in Plate 5, fig. 2, the origin and distribution being the same for both right and left sides, unless otherwise indicated.

The first pedal nerve, *1*, arises as a strong trunk from the outer anterior portion of the superior face of the pedal ganglia. It passes directly forward parallel to the bulbar aorta and gives off a slender external branch, *1a* close to its origin. This ramus is distributed mainly to the anterior region of the lateral retractor muscles of the head, a large branch also forming an anastomosis with the second pedal nerve, *2*, as shown in the figure. At about 9.0 mm. from its origin the main trunk of the first nerve bifurcates, its two subdivisions each dividing in turn almost at once. The four main branches thus formed are distributed to the most anterior portions of the foot.

The second pedal nerve, *2*, is strong, upon the left side being nearly as large as the first. It arises from the antero-lateral face of the pedal ganglion, just behind and external to the first nerve, and passes obliquely forward, receiving the anastomosing branch of the first, just above the lateral retractor of the head. Passing between the fasciculi of this muscle to its outer face, it courses forward between it and the body-wall, giving off branches to the lateral rectractor and to the ventro-lateral body-wall at the margin of the foot.

The third nerve, *3*, is made up from the union of a number of delicate roots. Upon the left side three of these may be distinguished, the first arising close above the origin of the second nerve, the second from the lateral face of the pedal ganglion, while the third is not a pedal nerve but arises from the left pleural ganglion (*pl. 1*). These unite in a common epineural sheath and are distributed to the lateral body-wall in front of the eye. On the right side at least three delicate roots arise from the pedal ganglion, while a fourth springs from the right pleural ganglion and joins the first three in a common sheath. The first root appears to maintain its separate existence, the remaining three, or possibly four uniting in a common trunk a short distance from the ganglion. The group sends an anastomosing branch to the first cerebral nerve, and is distributed to the lateral body-wall in front of the eye, and to the posterior retractor muscles of the penis-sheath.

The fourth pedal nerve, *4*, arises from the ventro-lateral surface of the pedal ganglion as a moderately strong trunk. It passes outward and forward below the lateral retractor muscle to the ventro-lateral body-wall, and curves

forward along it, sending off numerous branches to it and to the anterior end of the foot. This nerve may probably be considered to be the anterior pedal nerve proper, if such a one can be distinguished from the others sending branches to this region.

The fifth, or median pedal nerve, *5*, arises as a strong trunk from the ventro-lateral face of the pedal ganglion just behind the origin of the fourth nerve. It passes straight outward and downward, bifurcating into an anterior and a posterior ramus at the junction of the body-wall and the foot. These two divisions break up into numerous branches to the median and posterior regions of the foot.

Close behind the origin of the fifth nerve is given off a nerve of nearly the same size, the sixth pedal nerve, *6*, which likewise passes outward and backward. At about 10 mm. from its origin it divides into two nearly equal branches. The more anterior one of these curves outward and forward to the body-wall, forking as it reaches it. The anterior branch thus formed enters the wall slightly above the margin of the foot, and but slightly posterior to the level of the central nervous system. It then curves forward and dorsally, and ramifies among the deep muscles of the wall. Its fellow, the posterior branch of the anterior ramus, passes backward along the inner surface of the body-wall to which it gives off small branches, finally splitting up among the deep muscles.

The posterior main ramus of the sixth nerve courses backward, bifurcating in front of the origin of the lower group of lateral retractors of the head, the branches immediately entering the wall of the body and ramifying to the deeper dorso-lateral muscles.

The seventh pedal nerve, *7*, arises at the posterior outer margin of the ganglion, immediately above the origins of the fifth and sixth nerves, and is slightly thicker than either of them. It passes obliquely backward, and, not far from its origin, splits into three nearly equal divisions, the first two of which are distributed to the anterior and median dorso-lateral regions of the body-wall. The posterior division is distributed mainly to the body-wall above and in front of the origin of the head retractor muscles, though small branches are supplied to that muscle group itself. Several anastomoses are to be found with branches from the eighth and ninth nerves, such conditions being in fact of fairly common occurrence among the finer peripheral subdivisions of most of the nerves to the integument. The distal portion of the seventh pedal nerve of the right side also enters into important relations with the nerves from the parieto-visceral ganglia, (Plate 3, fig. 2). The three terminal subdivisions,

7a, *7b*, and *7c*, of the seventh pedal nerve, *7 ped.*, form anastomoses as follows:—the branch *7a* ramifies among the tubules of the organ of Bohadsch, *o. B*, also sending a branch to unite with the nerve *1a* from the first parietal nerve, *p. 1*; *7b* sends numerous branches into the organ of Bohadsch, *o. B*, and finally unites with the recurrent branch *2c* of the second visceral nerve; while *7c*, the more anterior terminal branch of the seventh pedal, sends twigs to the dorsal peritoneum, and anastomoses with a delicate median branch of the second parietal nerve, which is distributed to the same region. These relations are substantially the same as those brought out by the writer (1909, p. 53) for *Tethys dactylomela* and *Tethys cervina*, in which forms the organ of Bohadsch is shown to be innervated from both the right pedal and the left visceral ganglia. Plate 3, fig. 1 illustrates this arrangement for *T. cervina*. Here the third pedal nerve *3 ped*, sends the branches *3a* and *3b* to the organ of Bohadsch, *o B*, which is also innervated by the recurrent anastomosing branch *2c*, from the second visceral nerve, *v2*, of the left side. In Mazzarelli's (1890), study of the organ of Bohadsch in the Mediterranean Aplysiidae he describes the innervation as from the right pedal ganglion alone, and disputes the earlier statement of Vayssière (1885) as to its innervation from the left visceral ganglion. The present writer's previous position that both authors were in part correct is much strengthened by this similar condition of double innervation, found in the more distantly related Dolabellinae.

The eighth pedal nerve, *8*, arises just behind the sixth one, from the posterior outer margin of the pedal ganglion. It is of moderate size, and passes backward and dorsally along the body-wall, sending occasional branches to the retractor muscles of the head. The main nerve bifurcates as it enters the dorso-lateral body-wall, about midway of the length of the animal, its further subdivisions passing mainly to the parapodia. Two small anastomosing branches are also given off to the posterior subdivision of the seventh pedal nerve, before the latter reaches its distribution in the organ of Bohadsch.

The ninth, or posterior pedal nerve, *9*, is the largest nerve from the pedal ganglia. It arises from the posterior border of the ganglion and passes backward below the head retractor muscles to the posterior region of the foot, where it ramifies among its muscles and those of the adjacent body-wall. Close to the origin of the ninth nerve on the left side, but some distance from that point on the right one, a slender branch, *9a*, is given off. On each side the fibres of this delicate nerve may be followed back in the common trunk to the pedal ganglion. Upon the right side this branch forms an anastomosis with a

paired nerve arising from the parapedal commissure described below. It sends a branch to the peritoneum of the diaphragm-like septum of connective-tissue in front of the stomach, and is finally distributed to the head retractor muscle near its origin. Upon the left side the relations are similar, save that no branches to the diaphragm can be identified with certainty. The final termination is the same as that of the right side, an additional delicate branch being sent to the aorta. In Plate 5, fig. 2 these relations are shown in ventral view.

The marked asymmetry described by Amaudrut (1886) as existing in *D. rumphii* [= *scapula*], due to the large development of the third pedal nerve of the right side, was not found in *D. agassizi*. From his brief description without figures I infer that his third pedal nerve corresponds to what is here described as the ninth, and which I consider to be the posterior pedal nerve. It is practically alike upon the two sides in the present form, that of the right side being slightly stouter, but the peripheral distribution being the same. As no details are given by Amaudrut of the distribution of the other pedal nerves beyond slight mention of the second, I am unable to make any further comparisons of the two forms.

Parapedal commissure.— The slender parapedal commissure (Plate 5, fig. *2*, *p-p. c.*) arises from the median ventral face of each pedal ganglion, and forms a loop, 12 mm. in length, which encircles the anterior aorta below the pedal commissure. The point of origin of the parapedal commissure is near to that of the fifth and sixth pedal nerves. Close to its origin on either side the parapedal commissure gives off a slender nerve. That of the right side curves immediately to the aorta, and bifurcates at *a*, Plate 5, fig. 2, into an anterior and a posterior branch of equal size. The anterior branch courses forward along the ventral wall of the aorta which it supplies with fine nerves. The posterior branch passes backward along the aorta and soon divides into two nerves. One of these, *d*, diverges from the aorta and passes upward and backward into the connective-tissue diaphragm in front of the stomach. The other branch, *e*, continues along the right ventral border of the aorta upward and backward toward the heart. It sends no branches to the aorta, but gives off a nerve, *f*. to the diaphragm, and then forms an anastomosis with a branch of a pedal nerve, *9a*, the united nerve thus formed, *h*, passing dorsally in the diaphragm to the superficial peritoneum in which it ramifies.

Upon the left side the homologous nerve, *b*, from the parapedal commissure loops backward in the connective-tissue bordering the left margin of the aorta and follows its left pedal branch to the foot and body-wall, ramifying in the peri-

toneum of these regions. It also forms an anastomosis with a branch of the left posterior pedal nerve, *9a*, in a position similar to that entered into by its fellow of the opposite side.

From the loop of the parapedal commissure, a little to the left of its middle point, a slender unpaired nerve, *c*, is given off. It courses backward along the ventral surface of the head retractor muscles to a point below the anterior end of the ingluvies, where it curves downward and backward through the connective-tissue septum to the foot, ramifying there in the peritoneum.

Of the above nerves the second unpaired one was described by Amaudrut (1886) for Dolabella, and has been noted in various species of Tethys by Cuvier (1804), Von Ihering (1877), Vayssière (1885), Mazzarelli (1893), and the writer (1909). The paired nerves here described as arising from the parapedal commissure have not been found heretofore in any member of the group. It may possibly be a case of a fusion of a pedal nerve with the beginning of the commissure to such an extent that it appears to be a branch of the latter on leaving it, for the nerve-cells from which the fibres spring are without doubt to be found in the pedal ganglion itself.

Pleural ganglia.— The pleural ganglia rest upon the upper posterior face of the pedal ganglia, to which they are united by extremely short pleuropedal connectives. They are inclosed with the pedal ganglia in a close common investment of connective-tissue, so that they are not distinguishable until after careful dissection and clearing. They are ellipsoidal in form, strongly flattened dorso-ventrally, and about one fourth the size of the pedal ganglia, measuring approximately 1.3 mm. in width by 1.9 mm. in length. From the upper outer face of each ganglion is given off the strong cerebro-pleural connective, which, at first independent, soon joins the cerebro-pedal connective and passes around the oesophagus with it to join the cerebral ganglia on the dorsal side.

Pleural nerves.— Each of these pleural ganglia gives rise to two nerves. The first pair of these (Plate 2, fig. 1, *pl. 1*), arise from the antero-lateral face of the ganglia immediately in front of the origin of the cerebro-pleural connective. It is very delicate and passes outward, joining the third pedal nerve in a common sheath and has a common distribution with it, as already given above in the description of the nerves from the pedal ganglia.

From the inner posterior border of each pleural ganglion arises a long and strong connective, each passing back to unite with a peripheral group of ganglia, forming the visceral loop. That of the right side is the pleuro-parietal connective, *pl-par. con*, that of the left the pleuro-visceral connective, *pl-v. con.*

Their further relations will be taken up later in connection with the parieto-visceral ganglion complex.

Immediately above the origins of these connectives, on the dorsal surface of each ganglion, is found a delicate nerve, *pl. 2*, arising from two roots. These separate roots were only made out in strong sunlight and under a binocular dissecting microscope. One of them, the innermost, arises from the pleural ganglion itself, the other springs from the cerebro-pleural connective, as shown in Plate 2, fig. 1, *pl. 2*. The second pleural nerves thus formed diverge from the pleuro-parietal and pleuro-visceral connectives respectively, with which they are at first united in a broad web of connective-tissue, and pass backward and upward over the posterior visceral mass, above the spermatotheca and enter among the muscles of the dorsal body-wall, immediately in front of the pericardium.

Mazzarelli (1893) denies the existence of any nerves from the pleural (pro-to-visceral) ganglia in the Aplysiidae. The writer (1909) has found similar ones to those here described in *Tethys dactylomela* and *T. cervina*, and they have also been noted by Amaudrut (1886) for Dolabella. Further information as to the relations and functions of these nerves is very desirable, but the lack of suitable material has prevented it.

Buccal ganglia.— The buccal ganglia are situated upon the postero-inferior surface of the pharyngeal bulb, not upon the superior-posterior surface, as stated by Amaudrut (1886). They consist of a pair of rounded ganglia, strongly flattened dorso-ventrally, and connected by an extremely short commissure. When exposed in ordinary dissection nothing is seen of the ganglia proper, the dense connective-tissue capsule which covers them concealing their actual shape completely. The outlines of this capsule are indicated by the dotted lines on Plate 3, fig. 3. The form of the group so presented is a broad and flattened quadrilateral, with no indication of any division into right and left halves. The posterior border is slightly concave and is entirely free from the bulb, while the anterior one on the contrary is continuous with an overlapping fold of its ventral wall. The nerves from the lateral margin are connected at their bases by a web-like expansion of the capsule, which is prolonged out upon each of them as the nerve-sheath.

After the complex is removed from the animal, stained in paracarmine and cleared in glycerine, the actual flattened oval outline of the ganglia becomes visible, and it is seen that they are of much smaller dimensions than those shown by the external outline of the capsule, measuring but 1.5 mm. long and

3.0 mm. broad, while the apparent external dimensions reach a length of 3.0 mm. and a breadth of fully 5.5 mm. The ganglia are closely united by a very short and broad buccal commissure.

Buccal nerves.—From the buccal ganglia are given off three paired nerves and a single unpaired median one.

The anterior unpaired nerve (Plate 3, fig. 3, *b1.*) is completely concealed from view by the capsule. Though apparently a single unpaired nerve, it actually arises by a root from each ganglion, close in front of the commissure upon the dorsal surface. These separate roots at once fuse into a single median trunk which almost immediately bifurcates into two equal rami, that pass upward into the ventral wall of the bulb. Each gives off several delicate branches to the superficial wall-muscles, and then penetrates upward and outward to the rotella, to which each is distributed in a number of branches. Upon the dorsal surface of the first nerve, immediately before its bifurcation, a pair of very delicate branches, *b 1a*, are given off, which are distributed to the superficial muscles of the floor of the bulb immediately in front of the buccal ganglion. These are also shown in dorsal view in Plate 3, fig. 4, *1a.*

The paired nerves from the buccal ganglia in *Dolabella agassizi* appear upon their exit from the capsule as six independent nerves, corresponding to the number given by Amaudrut (1886). This is at some distance from the actual ganglia however, and in a cleared preparation the real origin of these nerves may be traced back to the ganglia proper, and the apparent number becomes reduced to but three main nerve-trunks upon each side. These nerves are numbered in sequence in Plate 3, fig. 3 as *b 2*, *b 3*, and *b 4*, *b 1* being the single median trunk just described.

The second buccal nerve, *b 2*, arises from the outer lateral margin of either ganglion. It bifurcates at a short distance, giving rise to a posterior ramus, *c–b*, *con*, which courses around the bulb dorsally and unites with the cerebral ganglia, forming the cerebro-buccal connective (Plate 2, *c–b. con.*). The anterior ramus of the second buccal nerve divides at once into two branches, *2c* and *2d.* The branch *2d* enters the large protractor bulbi muscle at its insertion into the pharyngeal bulb and gives off a number of fine branches to it, the main nerve passing on forward into the ventro-lateral muscles of the anterior portion of the bulb itself, a slender branch being continued forward and distributed to the anterior ventral protractor muscles of the bulb at their insertion into the latter. The branch *2c* passes obliquely forward and upward to the lateral wall, above the insertion of the lateral protractor bulbi muscle, giving off several

fine nerves to the superficial muscles of the bulb in this region, penetrates below the surface and continues forward to the ventral part of the anterior end of the bulb, ramifying there to it and to the mouth-tube.

The third buccal nerve, *b 3*, arises very close behind the second nerve and passes upward, parallel to the proximal portion of the salivary gland. It gives off a delicate branch to the superficial circular muscles of the posterior portion of the bulb, and to the duct of the salivary gland, and then divides into two main rami, the anterior one of which passes forward and upward to the superficial dorsal muscles of the bulb, while the posterior one passes dorsally and ramifies in the thin dorsal wall of the bulb directly beneath the cerebral ganglia.

The fourth buccal nerve, *b4*, arises from the outer posterior margin of the buccal ganglion, and bifurcates into two equal rami before emerging from the capsule. The more anterior of these, *4a*, curves upward along the inner margin of the salivary gland, which it closely follows to the entrance of its duct into the bulb, giving off numerous fine branches to the duct, and to the dorsal wall of the anterior end of the oesophagus, below the cerebral ganglion complex. The posterior ramus, *4b*, passes backward along the oesophageal wall, giving off a delicate branch to the salivary gland, and another to the anterior portion of the tube; the main trunk continuing along the side of the oesophagus throughout its whole extent, sending off numerous branches to it at intervals, which, anastomosing with those of its fellow of the opposite side, form a rich plexus in the oesophageal wall. Reaching the ingluvies the two trunks are prolonged over its wall to its junction with the thick-walled triturating gastric division. Here there is found a ring of nervous tissue surrounding the whole canal, in which the two nerves merge. From this nerve-ring numerous delicate nerves are given off to the gastric wall, forming a rich plexus, while four larger nerves approximately equidistant from each other, pass backward along the wall of the first triturating stomach. Beyond the posterior boundary of the first triturating division, branches are given off laterally from each of these, which anastomose mutually and form a second more irregular nerve-ring in the anterior wall of the second triturating stomach. From this second ring numerous nerves pass backward throughout the whole length of the intestine, giving off abundant irregular branches to its wall, which unite in extensive plexuses. A stronger laterally placed trunk on either side, while often obscure, still may usually be made out, as an indication of the primitive bilateral arrangement of the nerve distribution.

Parieto-visceral ganglia.—The parieto-visceral ganglion complex is situated

midway of the body-length at the posterior end of the anterior division of the body-cavity, being placed nearly transversely above the aorta, and immediately behind the anterior border of the liver, in front of and above the oblique body-septum, or diaphragm. Externally it is located by the anterior ends of the parapodia, being situated just below them and slightly to the right of the median line. The complex is of an elongated elliptical form, its double nature being indicated by the entrance of the connectives from the pleural ganglia, but no other external sign of its composition is evident. The left visceral ganglion is placed in front of the right parietal one, the larger and more conspicuous nerves emerging from the left end and doubling immediately around the aorta and to the rear. The two moieties are connected with the corresponding pleural ganglia of the central nervous system by long connectives, the right parietal ganglion to the right pleural one by the pleuro-visceral connective, Plate 2, fig. 1, *pl.-par. con*, the left visceral division to the left pleural ganglion by the pleuro-visceral connective, Plate 2, fig. 1, *pl.-v. con*. In addition to the figure just cited the complex appears in Plate 3, fig. 2, Plate 4, fig. 1, and Plate 5, fig. 4.

Visceral nerves.—From the left visceral ganglion two nerves arise. The first of these (Plate 3, fig. 2, *v 1*) is given off from the inner posterior end of the complex. It soon bifurcates into a more slender ramus which passes forward to the peritoneum of the dorsal body-wall, and a stronger one which is distributed to the vesicle of Swammerdam or spermatotheca, and its duct. The second visceral nerve arises as a very strong trunk from the posterior end of the ganglion (Plate 3, fig. 2, *v 2*, Plate 5, fig. 4). It at once divides into two equal rami, doubling around below the aorta and to the right, and diverging as they pass obliquely backward. The right one of these (Plate 5, fig. 4, *v. 2a*) crosses obliquely backward below the loops of the large hermaphroditic duct. Its distribution is best shown on Plate 3, fig. 2. It divides into two nearly equal trunks, one of which, *2b*, at once bifurcates into nearly equal branches, which pass backward and are distributed, the one to the rectum and the adjacent peritoneum, the other to the siphon and the peritoneum immediately surrounding it. The second trunk, *2c*, sends a branch, *2d*, to the peritoneum, and several minor ones to ramify among the tubules of the organ of Bohadsch, the extent of which is indicated by the dotted line, *o. B.* The remainder of the nerve curves forward and anastomoses with a branch of the seventh pedal nerve *7b*.

The left one of the two rami (Plate 3, fig. 2, *v 2b*, Plate 5, fig. 4, *v 2b*) of the second visceral nerve diverges backward from its fellow and sends off a

delicate branch to the peritoneum, another, *2b1*, branching to the distal end of the large hermaphroditic duct and to the peritoneum of the vesicle of Swammerdam, and then bifurcates equally. One of the branches thus formed, *2b4*, curves to the left and upward around the anterior border of the adnexed genital mass and penetrates the dorsal body-wall above the latter. Here it gives off slender branches to the vesicle of Swammerdam and to the peritoneum. The main trunk penetrates among the muscles forming the floor of the pericardial cavity, courses obliquely backward to its posterior wall, in which it again ascends to recurve obliquely to the right in the roof of the pericardium. It innervates the floor of the pericardium, the anterior end of the *crista aortae*, the beginning of the auricle, the roof of the pericardium, the reno-pericardial opening and its tube, and the kidney. The other branch, or genital nerve, *2b3*, passes directly backward and across the base of the adnexed genital mass to the genital ganglion group, *g. g.* This latter complex is shown on Plate 5 in fig. 4, *g. g*, and in more detail on a larger scale in fig. 1 of the same Plate. Here the delicate connective-tissue investment of the distal end of the small hermaphroditic duct has been dissected away, exposing the whole group of genital ganglia. Two of these, *g1* and *g2*, are fairly conspicuous (Plate 5, fig. 4), but the remaining ones, *g3* and *g4*, require careful dissection under high magnification for their detection. The genital nerve, *g. n*, the branch of the second visceral nerve just described, terminates in the largest of these genital ganglia, *g1*, from which the nerves, *a*, pass into the adjacent dorsal peritoneum, and the nerve, *b*, is sent to the small hermaphroditic duct. The remaining ganglia, *g2*, *g3*, and *g4*, are connected with *g1* in a complicated plexus from parts of which the nerves, *c*, pass on to the small hermaphroditic duct and the ovotestis, while the fine branches *d*, together with other still finer ones not figured, penetrate the adnexed genital mass.

Figure 1 of Plate 3 illustrates the parieto-visceral complex of *Tethys cervina*, as described by the writer (1909). It is here introduced to call attention to the homologies existing between this representative of the Aplysiinae and *Dolabella agassizi*. Comparing this with Plate 3, fig. 2 it is seen that the two visceral nerves in Dolabella represent the four shown in *Tethys cervina*, the second one in Dolabella being formed by the union of the second, third, and fourth of Tethys. Identical relations in the visceral innervation of the organ of Bohadsch and in the anastomosis of a branch of the second visceral with a pedal nerve are also evident, so that the double innervation of this organ from both visceral and pedal ganglia obtains in this subdivision of the family Aplysiidae, as well as in the more restricted Aplysiinae.

Parietal nerves.—The first parietal, or vulvar nerve (Plate 3, fig. 2, *p. 1*) arises from the ventral surface at the left or posterior end of the ganglion. It emerges from the capsule between the two ganglionic components of the parieto-visceral group, but slightly nearer the parietal one, into which it can be traced. It passes backward in the connective-tissue attached to the aorta (Plate 4, fig. 1, *p. 1*) to the dorsal body-wall, and thence directly to the anterior end and external opening of the large hermaphroditic duct. It gives off a branch laterally, which curves to the right and forward, uniting with the branch 7*a* from the seventh pedal nerve, which is distributed to the organ of Bohadsch, which relation is the same as that found in *Tethys cervina* (Plate 3, fig. 1), the pedal nerve in that instance being the third in serial order.

From the posterior end of the right parietal ganglion arises a single strong nerve, the second parietal, or osphradio-ctenidial nerve. Its general relations are shown in Plate 3, fig. 2, *p2*, and the detail of its ramification in Plate 4, fig. 1, *p2*. It curves backward along the left border of the aorta, crosses above it, and opposite the middle of the V-shaped heart penetrates the dorsal peritoneum, giving off the following branches:— Plate 4, fig. 1, *1*, a slender nerve to the peritoneum, *2*, a nerve which passes directly forward near the median line below the spermatic furrow, to which it ramifies, also sending off the branch *2a*, which fuses with a branch of the 7th pedal nerve, *7p*. The main trunk is markedly thickened near the origin of these branches, and bifurcates into the nearly equal divisions *3* and *4*. The ramus *3* forks into *5* and *6*, the first passing to the anterior portion of the mantle, the second to the outer face of the kidney, giving off the branch *7* to the ventral face of the same organ. The ramus *4* thickens decidedly, though no well-marked ganglion is formed, and gives off the branches *8* and *9* to the walls of the venous sinus at the base of the heart and to the mantle, and also numerous delicate short twigs which pass through the integument to the osphradium, at the anterior end of the ctenidium, indicated in the figure cited by the outline *osp*. Beyond the thickened portion the main nerve gives off the branch *10*, which ramifies to the roof of the branchial chamber above the ctenidium, and to the walls of the branchial sinus at its base. The main nerve-trunk *11*, now enters the ctenidium and continues as its chief ctenidial nerve, *ct. n*, along the greater curvature to its tip, giving off numerous lateral branches to its different divisions. Other than the smoothly outlined thickening indicated above there is no trace of a distinct osphradial or ctenidial ganglion.

Respiratory, Circulatory, and Excretory Systems.— The external

features of the respiratory system have already been given under the general discussion of the pallial organs.

The circulatory and excretory organs seem to be of the general type common to the Aplysiidae and present no characters so fundamentally different as to warrant a detailed discussion here.

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EXPLANATION OF THE PLATES.

PLATE 1.

PLATE 1.

Fig. 1. Dolabella agassizi, sp. nov.

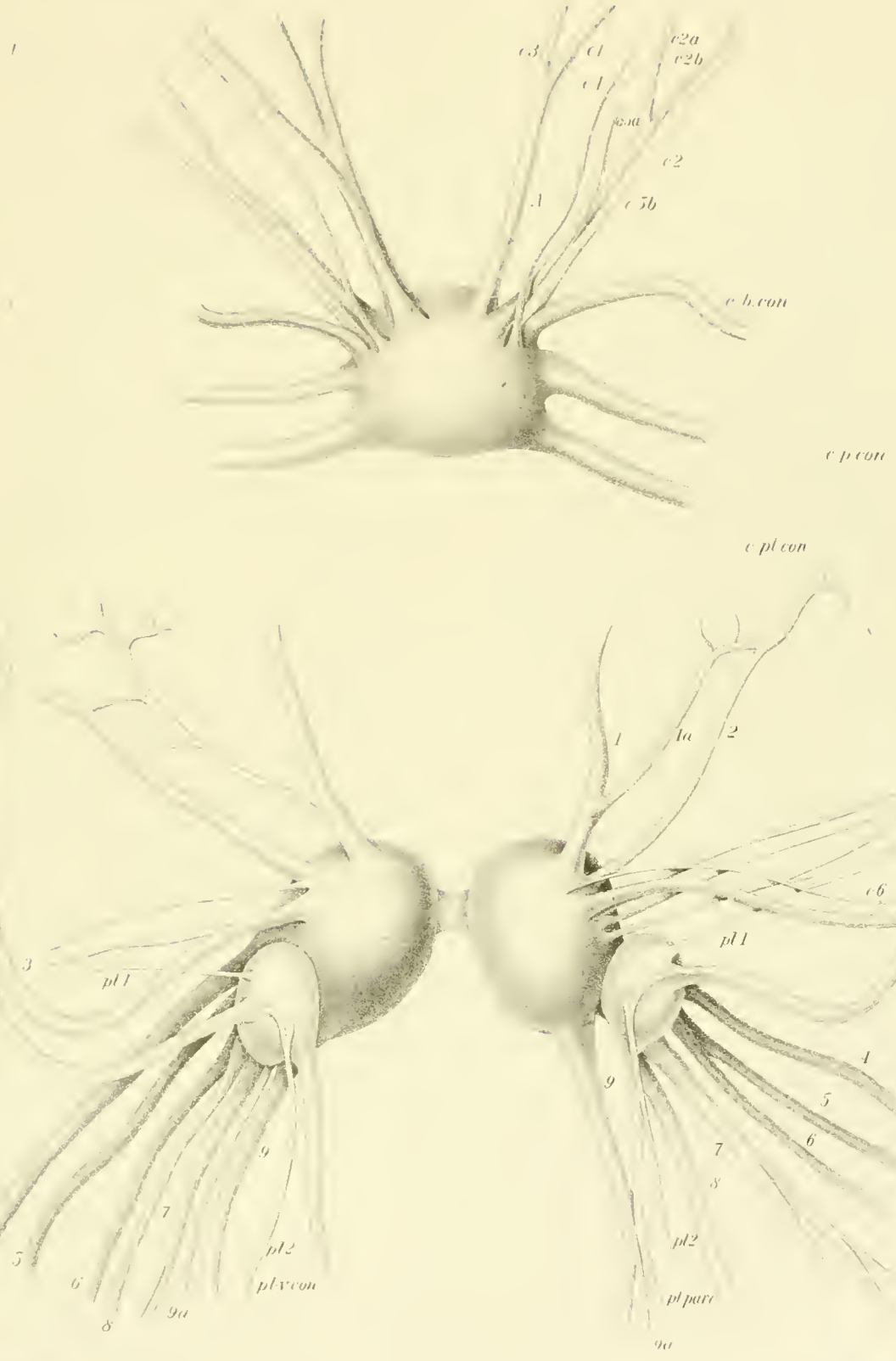
Fig. 1. Dorsal view, from a water-color drawing made by Alexander Agassiz from the living animal, at Easter Island. The scale of the drawing was not indicated, but it is approximately three fourths the size of the preserved specimen.

PLATE 2.

PLATE 2.

Fig. 1. Dolabella agassizi, sp. nov.

Fig. 1. The central nervous system in dorsal view. The connective-tissue capsules and sheaths of the ganglia and nerves have been dissected away, and are not represented in the drawing. The cerebral ganglia are shown in the upper part of the Plate, their nerves being indicated on the right side only by *c 1*, *c 2*, etc., the homologous nerves of the left side being symmetrically located and easily recognizable; *c-b con*, the cerebro-buccal connectives passing to the buccal ganglia (Plate **3**, fig. 3); *c-p con*, and *c-pl. con*, the cerebro-pedal and cerebro-pleural connectives, joining the cerebral to the pedal and pleural ganglia respectively, and shown on the lower half of the plate. Owing to the great length of these connectives their full extent is not represented, the interruption being indicated by the dotted portions. The pedal nerves are numbered serially in the order of their appearance from the ganglia, from in front backward; *pl. 1* and *pl. 2*, the first and second nerves from the pleural ganglia; *pl-par. c*, the pleuro-parietal connective of the right side; *pl-v. con*, the pleuro-visceral connective on the left. × 10.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c6
pl1
3
pl1
4
5
6
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8
9
9a
pl2
pl v con
pl2
pl par
9a

PLATE 3.

PLATE 3.

Fig. 1. Tethys cervina Dall and Simpson.

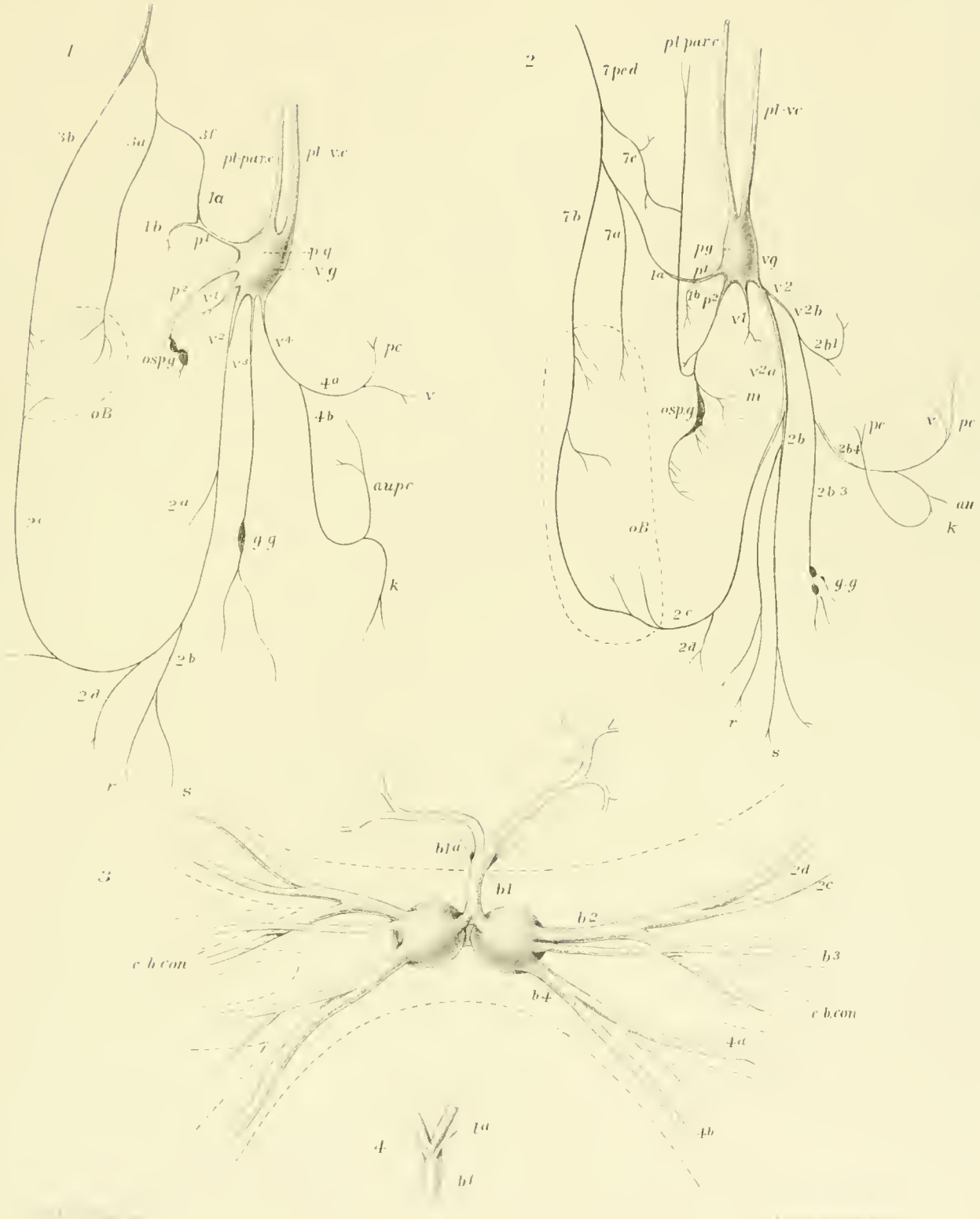
Fig. 1. Semidiagrammatic representation of the parieto-visceral ganglion complex as seen from below. The contour of the organ of Bohadsch is represented by the dotted line, *o B*. The anterior end of the animal is directed toward the upper margin of the Plate, the right side corresponding to the left one of the figure; *pl-par. c*, pleuro-parietal connective; *pl-v. c*, pleuro-visceral connective; *p. g*, right parietal ganglion; *v. g*, left visceral ganglion; *p1*, first parietal nerve, its branch *1 a* anastomosing with the branch *3 f* of the third pedal nerve, *3 ped*, its branch *1 b* forming the vulvar nerve; *p 2*, second parietal, or osphradio-ctenidial nerve; *osp. g*, the osphradium and its ganglion, the fine terminal nerves passing to the ctenidium; *v. 1*, first visceral nerve, to the spermatotheca and its duct; *v. 2*, the second visceral nerve, *2 a*, its hepatic branch, *2 b*, its main ramus, forking to the rectum, *r*, and siphon, *s*, and the adjacent peritoneum; *2 c*, its recurrent branch to the organ of Bohadsch and anastomosing with *3 b*, the branch of the third pedal nerve, *3 ped*, to the same organ; *v 3*, the third visceral nerve, supplying the genital ganglion, *g.g*, and the reproductive tract; *v. 4*, the fourth visceral nerve, branching into *4 a*, to the ventricle, *v*, and the pericardium, *p c*, and *4 b*, to the auricle and pericardium, *au. pc*, and to the kidney, *k*.

Fig. 2–4. Dolabella agassizi, sp. nov.

Fig. 2. A similar representation of the parieto-visceral ganglion complex. The abbreviations used in Fig. 1 apply to this figure except that the second, third, and fourth visceral nerves arise by a single trunk, *v. 2*, which bifurcates into *v. 2 a* and *v. 2 b; v. 2 a* has relations similar to *v. 2* of the preceding figure, save that its recurrent branch to the organ of Bohadsch forms an anastomosis with a branch of the seventh, *7 ped*, instead of the third pedal nerve; *v. 2 b* gives off a branch, *2 b 1*, to the peritoneum of the spermatotheca, another, *2 b 3*, to the genital ganglion complex, corresponding to the third visceral nerve, *v. 3*, of the preceding figure, while the remainder, *2 b 4*, representing the fourth visceral nerve, *v. 4* of Fig. 1, is like it distributed to the heart, pericardium, and kidney.

Fig. 3. Buccal ganglion complex as seen in dorsal view, *i. e.* the face in contact with the pharyngeal bulb. The outline of the connective-tissue sheaths of the ganglia and nerves is indicated by the dotted lines. The nerves are numbered serially *b. 1* to *b. 4*, and are described fully in the text. The second nerve gives off a branch, *c-b. con*, which passes around the pharyngeal bulb to the dorsal side and unites with the cerebral ganglia as the cerebro-buccal connective, (*c-b. con*, Plate 2, fig. 1); *b 1 a*, superficial branches of the first buccal nerve, *b 1*, shown in detail from the ventral surface in fig. 4. × 8.

Fig. 4. Ventral surface of the first buccal nerve, *b 1*, showing the origin of its superficial branches, *1 a*. × 8.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3f
pl parc
pl vc
1a
1b
pl
p q
v g
p2
v1
v2
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ospg
pc
4a
v
4b
oB
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2b 3
an
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s
3
b1a
b1
b2
2d
2c
c h con
b3
b4
c h con
4a
4b
4
1a
bf

PLATE 4.

PLATE 4.

Fig. 1–3. Dolabella agassizi, sp. nov.

Fig. 1. Detail of the distribution of the osphradio-ctenidial nerve as seen from below; *au*, auricle; *v*, ventricle; *c. a*, crista aortae; *ao*, aorta; *v. a*, visceral artery; *g. a*, gastric artery; *g*, genital artery; *p. b*, dotted line indicating the boundary of the pericardium; *o. B*, dotted line indicating the boundary of the organ of Bohadsch; *s. b*, dotted line indicating the boundary of the shell; *r-p. o*, reno-pericardial opening. The parieto-visceral ganglion complex lies above the main aortic trunk at the top of the figure, the left visceral ganglionic moiety lying in front of the right parietal portion. At their left anterior ends they are joined by their respective connectives from the pleural ganglia (Plate **2**, fig. 1, *pl-v. con*, *pl-par. con*); *v. 2*, the second visceral nerve, branching at once into *v. 2a* and *v. 2b*, which are distributed (Plate **3**, fig. 2); *p. 1*, first parietal, or vulvar nerve; *p. 2*, second parietal, or osphradio-ctenidial nerve. The main branches of this nerve are numbered in series; *1* to peritoneum; *2* to the middorsal peritoneum and the integument forward, giving off a branch *2a*, which anastomoses with a twig from the seventh pedal nerve, *7 p*. The branch *3* bifurcates into 5 and 6, the first passing to the anterior portion of the mantle, while the second passes to the outer face of the kidney, giving off the branch *7* to its ventral face on the way. The main trunk, *4*, now thickens decidedly and gives off *8* and *9* to the venous sinus at the base of the heart and to the mantle. Numerous minute short branches pass to the osphradium, *osp.*, shown here in outline. The branch *10* ramifies to the wall of the branchial chamber above the ctenidium, and to the walls of the branchial sinus at its base. The main trunk, *11*, now enters the ctenidium, *ct*, shown here in outline, and continues as the chief ctenidial nerve *ct. n*, to its tip, giving off numerous fine branches on the way. No distinct osphradial nor branchial ganglia other than represented in the thickened nerve-trunk itself are to be found. × 2.

Fig. 2. Ventral view of shell. × 1.7.

Fig. 3. Detail of common genital opening. The anterior end is directed toward the upper side of the figure; *a*, the integumental fold continued forward from the region of the siphon, as shown at *g*, (Plate **6**, fig. 1), along the floor of the pallial cavity and forming the dorsal margin of the genital opening. From its anterior curvature the dorsal or left ridge, *l*, of the genital furrow extends forward, approaching its fellow, *r*, of the right side, which is a continuation of the incomplete septum partially dividing the common genital opening into a dorsal and a ventral portion. × 3.

1
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v2b
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PLATE 5.

PLATE 5.

Fig. 1–5. Dolabella agassizi, sp. nov.

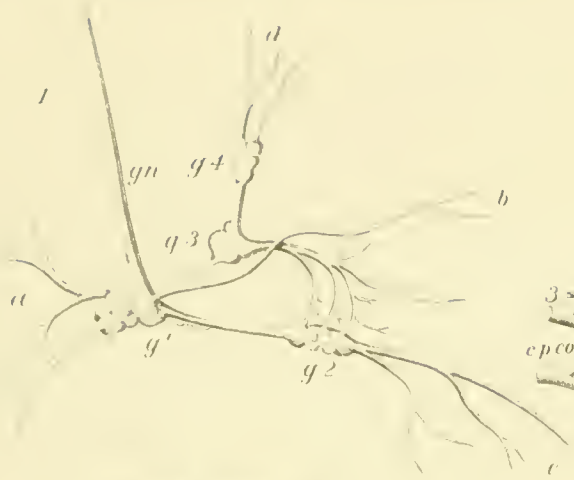
Fig. 1. Genital ganglion complex; *gn*, the genital nerve from the visceral ganglion (Plate **3**, fig. 2, *2 b 3*), terminating in a group of ganglia at the right margin of the adnexed genital mass (*cf.* Plate **5**, fig. 4, *g.g.*); *a*, fine nerves to dorsal peritoneum; *b*, nerves ramifying to the small hermaphroditic duct; *c*, nerves to the small hermaphroditic duct and to the ovotestis; *d*, nerves to the adnexed genital mass. × 50.

Fig. 2. Ventral view of central nervous system to show the relations of the parapedal commissure; *ao*, aorta; *s-b. a*, subbulbar artery; *l. p. a*, left pedal artery; *r. p. a*, right pedal artery; *p-p. c*, parapedal commissure, connecting the two pedal ganglia, shown above the aorta; *a* and *b*, paired nerves arising from the parapedal commissure; *d*, *f*, branches to diaphragm; *h*, branch to peritoneum; *c*, the unpaired median nerve from the same source; *1–9*, pedal nerves in ventral view. × 5.

Fig. 3. The four innermost lateral teeth of the thirtieth row of the radula seen obliquely from above. The teeth are numbered from within outward. The hook of the fourth tooth is double and the tip of the base of the same is also bifid (*cf.* Plate **5**, fig. 5). × 100.

Fig. 4. Reproductive system as seen from below, the parts lying in their natural relations; *sm. h. d*, the small hermaphroditic duct, its free end, *ov*, arising in the ovotestis, which is not represented, the closely convoluted turns of the duct narrowing on reaching the right posterior angle of the adnexed genital mass, *a. g. m.* It passes diagonally forward across the ventral face of the latter, forms a loop upon its dorsal surface and returns ventrally as *sm. h. d'*, to open into the fertilization-chamber, *f. c.*; *c. d*, copulatory duct opening into the fertilization-chamber and receiving the long duct of Cuvier, *d. C.*, from the spermatocyst, *sp. c.* Into the fertilization-chamber also open the convoluted portion of the nidamental gland dimly seen in the anterior part of the concave face, and the albumen gland, not visible in this view; *ov-sp. d*, the ovospermatic duct, the continuation of the spiral portion of the nidamental gland into the large hermaphroditic duct, *l. h. d*; *r. s*, its blind sac-like diverticulum, the seminal receptacle, near the distal end; *sp. th*, the spermatotheca, or vesicle of Swammerdam, opening by its long slender duct, into the distal end of the large hermaphroditic duct; *i*, edge of a small flap of integument cut from the body-wall, through which the large hermaphroditic duct opens in the common genital orifice; *pl. v. con*, the left pleuro-visceral connective; *pl. par. con*, the right pleuro-parietal connective; *l. v. g*, left visceral ganglion; *r. p. g*, right parietal ganglion; *v. 1*, first visceral nerve to spermatotheca; *v. 2a*, right main branch of second visceral nerve, its branch *v. 2a'*, to the organ of Bohadsch etc., and *v. 2a''* forking to rectum and anus; *p. 1*, first parietal nerve to vulvar region; *p. 2*, second parietal, or osphradio-etenidial nerve; *v. 2b*, left main branch of second visceral nerve, ramifying to the genital ganglia, *g. g.*, and to the heart, pericardium, kidney, etc. × 1.5.

Fig. 5. Four innermost teeth of the fifty sixth row of the radula, corresponding in position to those shown in Fig. 3. The same double characteristics appear in the fourth tooth that were found in the preceding row, shown in Fig. 3, and in all the intervening ones. × 100.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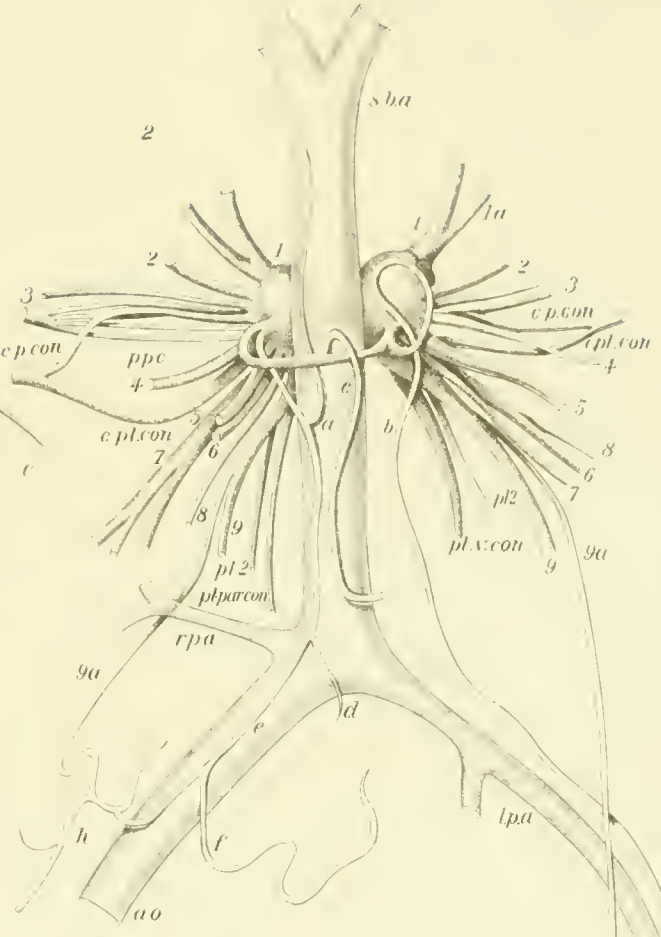
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ppc
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c.pl.con
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pl2
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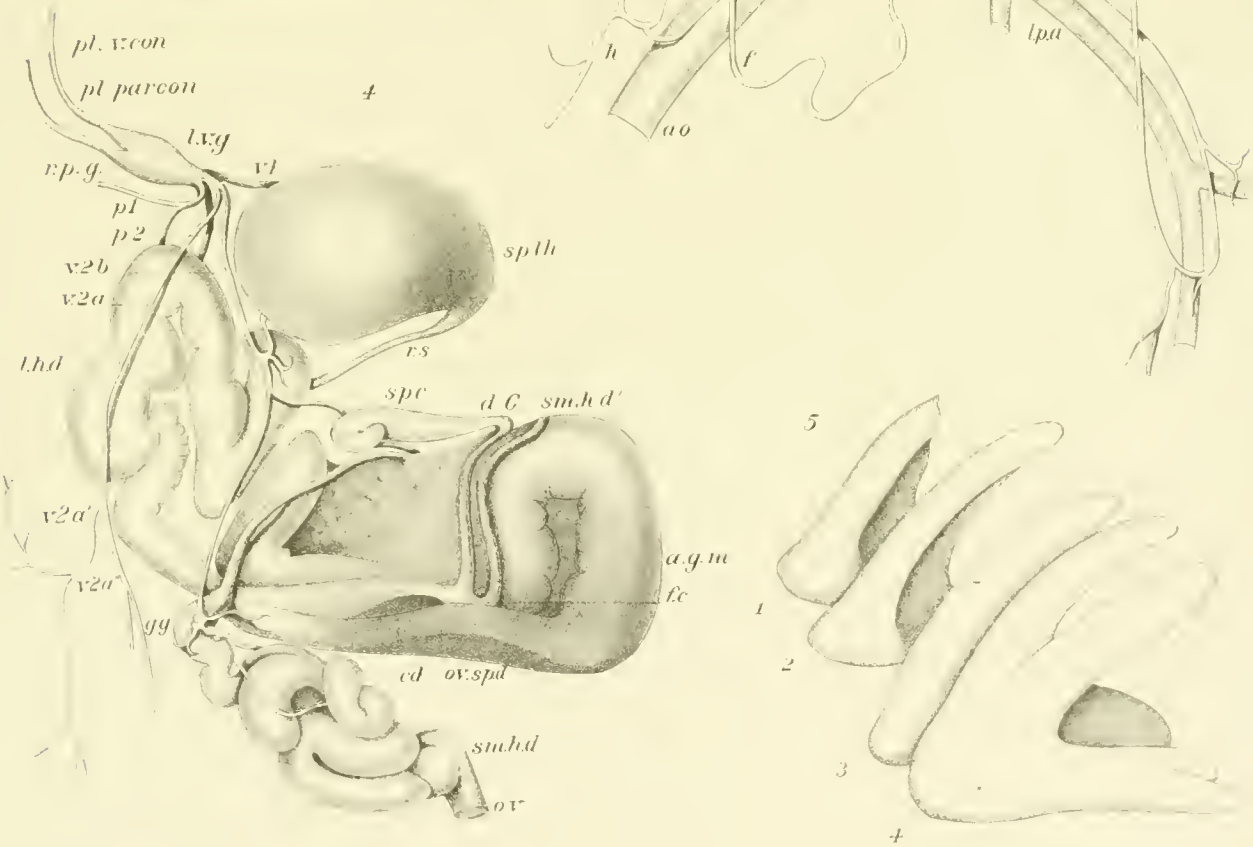
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PLATE 6.

PLATE 6.

Fig. 1–9. Dolabella agassizi, sp. nov.

Fig. 1. Diagram showing the relations of the pallial organs; *a*, inner boundary of base of parapodia; *b*, projection of outline of posterior body-disc upon underlying organs; *k*, similar projection of the upper margin of parapodia, continuous in front as a low ridge; *c*, outline of boundary of shell; *d*, right margin of mantle, extending from between the anterior ends of the parapodial lobes backward, its posterior margin reflexed dorsally at *e*, thence continued transversely and rising into the siphon margin at *s*; at the posterior edge of the siphon base it becomes nearly indistinguishable, but may be followed as a faint elevation to the right behind the anal opening, *f*, thence merging into a strong fold, *g*, which curves forward along the floor of the pallial chamber to the reproductive opening, *h*, where it is continued around as its front margin and disappears within it (*cf.* Plate **4**, fig. 3); *i*, genital furrow, extending forward from the genital opening, *h*; *l*, margin of the shell-foramen; *n*, cushion-like prominence at bottom of siphon. Natural size.

Fig. 2. Typical lateral tooth from posterior region of radula in side view, *a-b*, base; *c*, tip of hook. × 100.

Fig. 3. Median tooth from 12th row of radula, in face view. No indication of a hook, it being worn away probably. × 175.

Fig. 4. Median tooth from 13th row of radula. × 175.

Fig. 5. Diagram of the pallial cavity; the mantle being cut away along the double line *m*, exposing the underlying ctenidium; *a*, outline of inner boundary of base of parapodia; *k*, projection of free upper margin of parapodia upon the underlying organs continuous in front beyond the pallial cavity; *b*, outline of projection of the margin of the posterior body-disc; *m*, cut edge of mantle, the incision being carried around close to the origin of the left attached margin of the mantle from the body-wall, thus laying open nearly the whole extent of the upper gill-cavity, except at the left posterior margin, where it reaches slightly farther back; *af*, afferent blood-vessel to ctenidium, *cf*, efferent blood-vessel to the same. That portion of the ctenidium lying to the right of a line joining *af* and *ef* projects freely into the pallial cavity, that to the left of the same is attached along its margin to the body-wall; *h*, common genital opening, its borders leading forward as the dotted lines to continue as the external spermatic groove, *i*, to the right side of the head; *s*, siphon; *c*, the cushion-like prominence at the base of the siphon, directly below the posterior rounded opening between the parapodia; *o*, osphradium. Natural size.

Fig. 6. Median tooth from 20th. row of radula in side view. A slight median hook present, but is worn; the anterior end of the thick basal portion is curved upward. × 175.

Fig. 7. Median tooth from 23rd. row of radula in face view. × 175.

Fig. 8. Median tooth from 31st. row of radula in side view. × 175.

Fig. 9. Median tooth from 59th. row of radula in side view. The hook here reaches its greatest development. × 175.

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PLATE 7.

PLATE 7.

Fig. 1–4. Dolabella agassizi, sp. nov.

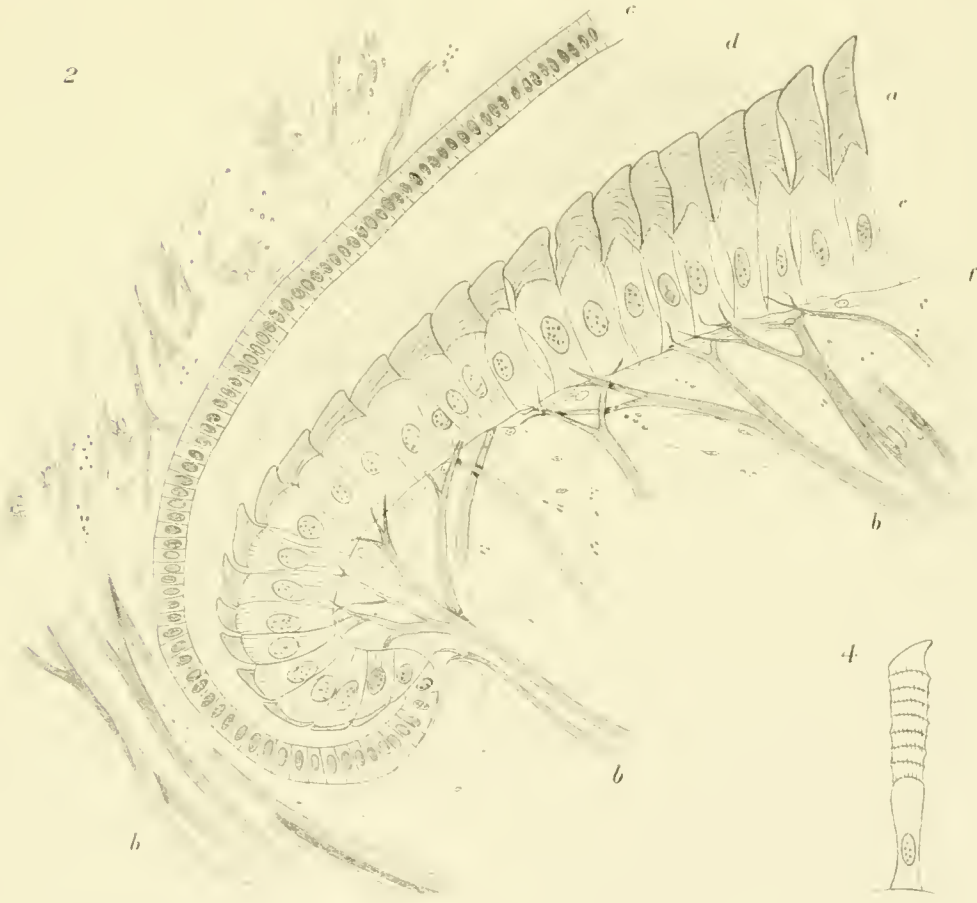
Fig. 1. Section transverse to long axis of mandible, about midway of its length (*cf.* Plate 8, fig. 5, *m.*); *a*, anterior or oldest border, the worn and broken rodlets borne on a thick basal cuticula, *b*; *c*, posterior or youngest border of the mandible, the short rodlets being formed in a deep sulcus upon the distal ends of the epithelium cells, and progressively increasing in length forward for about one half the width of the mandible; *d*, thick striated cuticle overlying the rodlets, secreted by the epithelium of the upper side of the sulcus; *e*, connective-tissue and muscle-fibres of the integument. × 22.

Fig. 2. Detail of innermost portion of mandibular sulcus; *a*, mandibular rodlets, cuticular differentiations upon the distal ends of the epithelium cells, *e*; *c*, epithelium of upper side of the sulcus which secretes the thick stratified cuticle, *d*, filling the space above the rodlets in the sulcus; *b*, muscle-fibres of the integument, many passing up through the basement-membrane and the compact layer of connective-tissue *f*, to terminate among the epithelial cells (*cf.* Plate 8, fig. 1 and 3). × 180.

Fig. 3. One of the longest of the mandibular rodlets, from the middle region of the mandible. The rodlet is still in contact with the epithelium-cell which produced it, and shows distinct stratification into layers as well as fainter longitudinal striation. × 180.

Fig. 4. A much shorter rodlet from a point toward the bottom of the sulcus, drawn at the same magnification as the preceding figure. The basal cell is proportionately much larger. × 180.

1
d
a
c
c
b


2
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f
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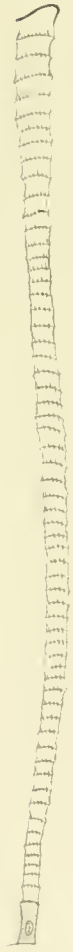
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4

PLATE 8.

PLATE 8.

Fig. 1–3. Dolabella agassizi, sp. nov.

Fig. 1. A group of seven epithelial cells from the mandibular sulcus region. Only the basal portion *a*, of the cuticular rodlets is shown; *f*, basal stratum of connective-tissue; *b*, *b*, two groups of muscle-fibres, the freely branching ends of which penetrate the basement-membrane and ramify around the basal ends of the epithelium-cells. In order to follow these branchings the focus has been changed slightly in drawing. The longitudinal fibrillation of the cytoplasm of the epithelial cells appears to be continuous beyond their distal ends into the cuticle itself. Celloidin section, Mallory's connective-tissue stain. × 500.

Fig. 2. Large subepithelial gland-cell from near base of palatal flap. The epithelium is not represented, being stripped off from the basement-membrane, *d*; the nucleus of the cell does not lie in the plane of the section. The dilated proximal end of the cell shows clear reticular cytoplasm with deeply staining nodal points. The region *b* is filled with a homogeneous secretion, which exudes from the tip of the cell at *a*, and passes up between the epithelial cells to their free surface. × 500.

Fig. 3. Three epithelial cells from near the bottom of the mandibular sulcus; *a*, the short cuticular rodlets; *f*, the basal stratum of compact connective-tissue, through which pass the richly branched ends of two muscle-fibres, which terminate in it and between the basal ends of the epithelial cells *e*. Fig. 1 and 3 show that a considerable amount of shrinkage has taken place in the epithelium, which has rendered the termination of the muscle-fibres more evident. Hansen's iron hematoxylin and chromotrop 2B. × 500.

Fig. 4. Dolabella hasseltii (Férussac).

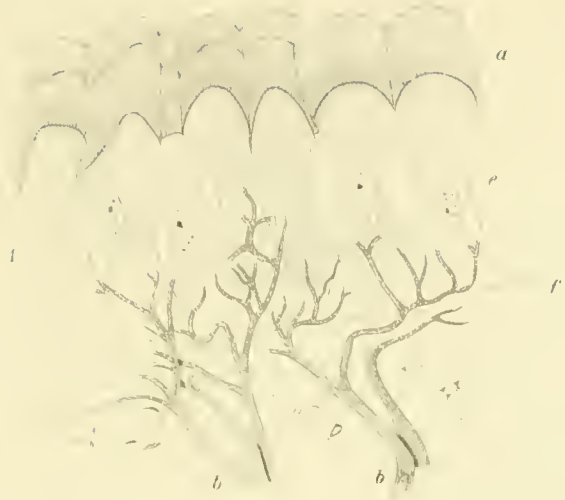
Fig. 4. Cross-section of the pharyngeal bulb, taken in the region of the mandibles to show their relations; *a*, outline of pharyngeal bulb; *c*, its lumen; *m*, mandibles, *g*, mandibular sulcus in which the rodlets are produced. The plane of this section is slightly posterior to the dotted line indicating the mandible *m*, in Fig. 5. × 12.

Fig. 5–7. Dolabella agassizi, sp. nov.

Fig. 5. Semidiagrammatic dorsal view of the interior of the pharyngeal bulb. The bulb has been opened by a median dorsal longitudinal incision, and the sides have been reflected; *m*, the mandibles; *l. f*, the palatal folds of the dorsal wall of the bulb, thickly set with the palatal spines; *f*, a transverse ridge in the dorsal wall connecting the palatal folds; *oe*, the oesophageal end of the bulb. The radula is seen in the centre of the organ, its anterior end buried in a deep curved groove. × 3.

Fig. 6. A group of the numerous subepithelial gland cells imbedded in the connective-tissue of the palatal flap, near the free margin. × 500.

Fig. 7. Surface view of a portion of the mandible near its posterior border; *a*, youngest rodlets; *b*, older ones. × 90.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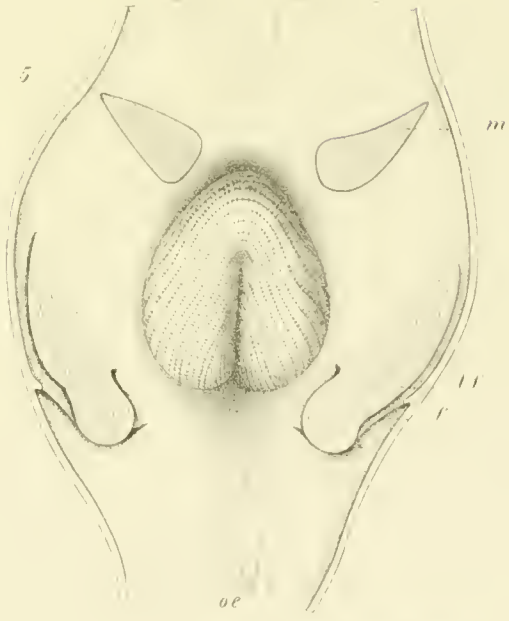
m
f
oe

PLATE 9.

PLATE 9.

Fig. 1–8. Dolabella agassizi, sp. nov.

Fig. 1. Single palatal spine, detached from the epithelium, but still imbedded in the common cuticula of the palatal flap. × 170.

Fig. 2. Early stage in the formation of a palatal spine. The spine here appears as a slightly thickened cap on the distal end of the granular basal cell. The thick common cuticula overlies all the epithelial cells of the figure, but is not here represented. × 175.

Fig. 3. Base of palatal spine, showing its relation to the basal matrix-cell, and to the general columnar epithelium. Part of another basal cell is shown at the left, its spine not being visible in the section. × 175.

Fig. 4. A later stage than that shown in the preceding figure, two layers of the young spine having been formed. × 175.

Fig. 5. A still later stage of the same, the section passing to one side of the nucleus of the basal matrix-cell. × 175.

Fig. 6. Later stage of the same process. The spine and basal cell have both increased in size. The cytoplasm of the matrix-cell contains numerous irregular vacuoles and is coarsely granular. × 175.

Fig. 7. Section across the long axis of the palatal fold as seen under low magnification; *a*, dorsal surface, forming part of the floor of the pharyngeal duct. The one-layered columnar epithelium *c*, bears a slight cuticula on the dorsal side, *a*, which thickens greatly on the ventral surface, *b*, and contains the palatal spines, differentiated in its substance, and resting upon the epithelium, or raised above it, and projecting freely; *c*, the free margin of the palatal fold; *d*, section of a salivary duct. × 18.

Fig. 8. Detail of fully formed palatal spine showing its relation to the epithelium and to the common thick striated cuticula, *c*, to the surface of which it does not yet extend, being still in contact with its matrix-cell, *b*. × 220.

1
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5
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7
8
a
b
c
d
e

PLATE 10.

PLATE 10.

Fig. 1–10. Dolabella agassizi, sp. nov.

Fig. 1. Outline of the gastric armature. The stomach has been slit lengthwise and opened out flat; *a*, posterior end of oesophagus; *b*, the slightly marked ingluvies; *c*, the first triturating stomach with the outlines of the bases of the gastric teeth; *d*, the second triturating stomach, larger and thinner walled than the preceding, the basal outlines of the very numerous but minute teeth not being apparent in this magnification.

Fig. 2. *a*, one of the medium sized gastric teeth seen in side view; *b*, the same from above, the four sided pyramidal form being well marked. × 6.

Fig. 3. Two of the small conical gastric teeth from the anterior portion of the first triturating stomach. × 6.

Fig. 4. *a*, one of the more compressed gastric teeth from the front part of the first triturating stomach; *b*, the same tooth from above. × 6.

Fig. 5. One of the largest gastric teeth seen from the side and below. × 6.

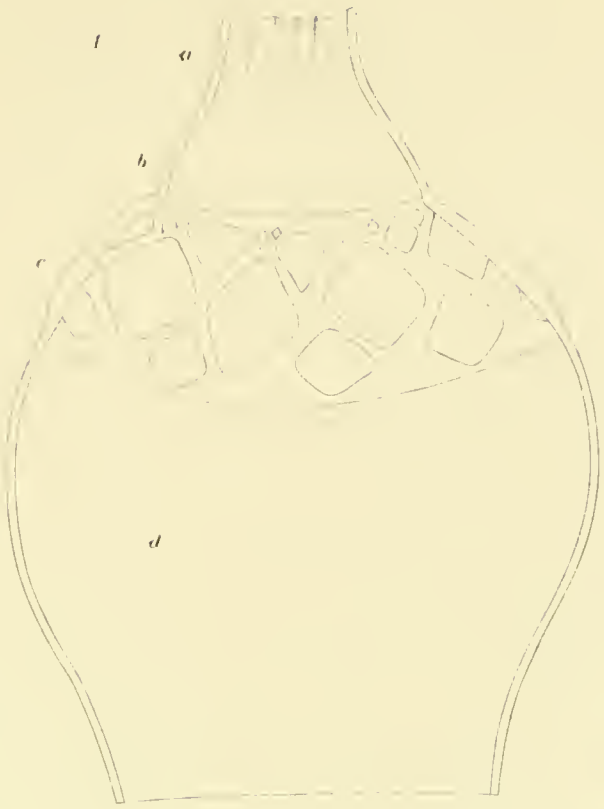
Fig. 6. Three of the numerous small conical teeth characteristic of the second triturating stomach. × 6.

Fig. 7. Epithelium-cells from just beyond the base of the palatal fold on the dorsal side of the buccal cavity. Drop-like secretion products are seen passing out from the distal ends of the cells and gradually merging into the common cuticle; *c*, outer border of the cuticle. × 500.

Fig. 8. A medium sized gastric tooth from the first triturating stomach in side view. × 6.

Fig. 9. A slender palatal spine from the basal region of the palatal fold; *e*, epithelium; *c*, surface of cuticle; *b*, basal or matrix-cell of the spine. × 6.

Fig. 10. The gastric tooth of Fig. 8 above, but here shown in surface view. × 6.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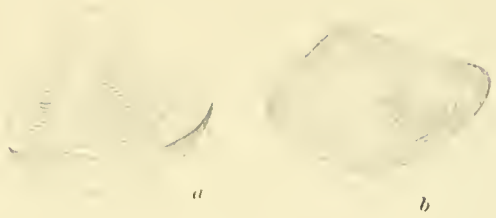
a
b
c
d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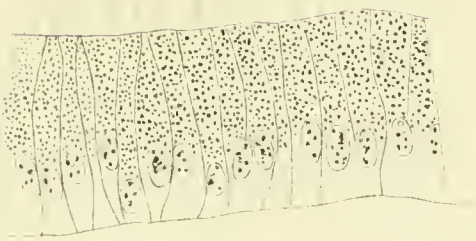
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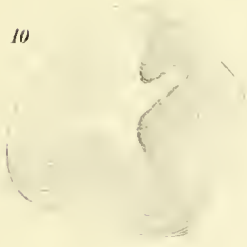
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9
c
e
b

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